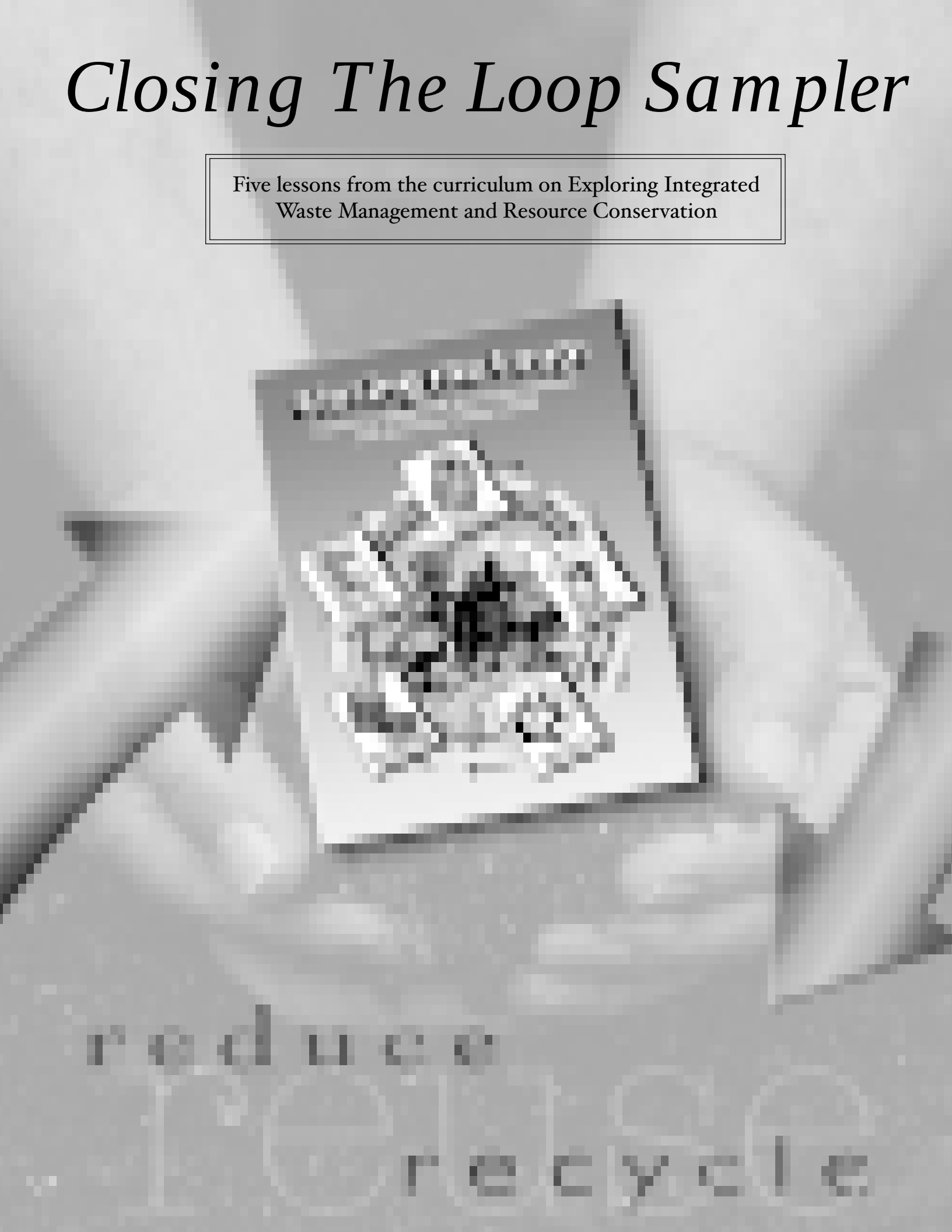
Closing The Loop Sampler

Five lessons from the curriculum on Exploring Integrated Waste Management and Resource Conservation



Dear Educators and Local Government Representatives

The California Integrated Waste Management Board and the California Department of Education are offering a sample of our highly acclaimed integrated waste management curriculum called *Closing the Loop: Exploring Integrated Waste Management and Resource Conservation*. This is a K–6 grade curriculum that was chosen by California environmental educators who evaluated a wide collection of integrated waste management materials using California education standards and frameworks.

The Board's first edition of *Closing the Loop* was originally published by an environmental education organization in Ohio. CIWMB obtained permission to customize *Closing the Loop* as a K–12 curriculum for California. Most recently, the 2000 edition has been rewritten into two modules that target K–3 and 4–6 grade levels. It was again field-tested by California schools and revisions were made before it was finalized and printed.

This free sample includes five of the lessons that you will find in the complete curriculum. These lessons, like all others in *Closing the Loop*, are hands-on and interdisciplinary and provide instruction on a broad spectrum of integrated waste management concepts. This sampler includes...

From Module K–3:

"What are Natural Resources?"

"Making Recycled Paper by Hand"

"The Basics of Vermicomposting"

And From Module 4–6:

"Away to the Landfill"

"Packaging—What a Waste!"

Give these lessons a try. If you are interested in receiving a full *Closing the Loop* curriculum to incorporate into your classroom teaching strategies, contact the Integrated Waste Management Board to schedule a workshop. Workshops are provided free of charge and all participants are given a complimentary copy of the complete curriculum. These workshops are interactive and engage teachers in hands-on activities. Workshops can be coordinated through teacher in-services, district training programs, or education association conferences.

The energy challenge facing California is real. Every Californian needs to take immediate action to reduce energy consumption. For a list of simple ways you can reduce demand and cut your energy costs, see our Web site at www.ciwmb.ca.gov.

We're waiting to hear from you!

Here is our contact information

California Integrated Waste Management Board

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(916) 341-6769

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Table of Contents

Note: No appendices are included in this *Sampler.* You may access the complete appendix via our Web site at www.ciwmb.ca.gov / Schools / Curriculum / CTL / default.htm. For an overview of the appendix, turn to the last page.

Introduction to *Closing the Loop:*
Exploring Integrated Waste Management and Resource Conservation
Kindergarten Through Grade Six
A Conceptual Approach with Project-Based Learning

The *Closing the Loop* (*CTL*) curriculum is designed to introduce students to integrated waste management through awareness, understanding, and action, and to encourage students to address today's solid waste problems. The lessons focus on becoming aware of natural resources and understanding alternatives to burying waste through reducing, reusing, and recycling, therby conserving natural resources and extending the life of landfills.

By using *CTL*, teachers will be following recommendations from California's newly adopted content standards and curricular frameworks in a conceptual, interdisciplinary, and hands-on manner. Through specific projects, students apply what they have learned in the classroom and learn to follow certain practices in integrated waste management. Some project-based lessons are service-learning oriented, and in these lessons students participate in improving the environment in their school and community and have opportunities to educate others about what they have learned.

In spring 1996, the staff at the California Integrated Waste Management Board (CIWMB) Public Education Assistance Section decided to revise and update the existing *Closing the Loop* curriculum. The copyright for *Closing the Loop* was acquired by the CIWMB. The project director for the 2000 edition of *Closing the Loop* was Tricia Broddrick, and the project manager was Cara Morgan. Olga Clymire, an environmental education curriculum writer with the Lake County Office of education, was hired to make the revisions. Leslie Comnes, Education Writing Consultant, and Amber Robinson-Burmester, Integrated Waste Management Specialist, updated the Appendix. In 1998 Amber Robinson-Burmester took over the duties as project manager.

The main goals for those preparing the 2000 edition of *Closing the Loop* were to revise the original *CTL* lessons to make them more applicable to California's content standards and curricular frameworks; provide additional lessons in integrated waste management, especially for teachers of kindergarten through grade three; develop concepts (main ideas) for each lesson; select children's literature and reference books and videos to support the *CTL* lessons; and include suggestions for project-based learning. These goals were determined by a group of educators, which included teachers and representatives from the California Integrated Waste Management Board and the California Department of Education. This group also recommended separating the old *Closing the Loop* lessons into two modules: one for teachers of kindergarten through grade three and one for those teaching grades four through six.

Later, it was recommended that the following elements of an effective environmental education program be incorporated in the *CTL* units:

- Using thematic instruction
- Providing opportunities toeach lessons in built and natural settings
- Involving students in lifelong learning about local and global issues
- Engaging in ecologically responsible action projects
- Challenging students to use higher order thinking processes in the context of community issues
- Using hands-on and minds-on activities in classroom and field investigations

Forty-nine teachers throughout California fieldtested the lessons in the revised version of *Closing the Loop*. The goals of this field test were to:

- Verify that the revised *Closing the Loop* lessons provide an enjoyable and successful learning experience for students.
- Make the lessons more applicable to the content and pedagogy recommended in the content standards and frameworks adopted by the California State Board of Education.

- Identify changes and corrections that need to be made to make the curriculum effective for classroom use.

Teachers who field-tested the new *Closing the Loop* said that the lessons were easy to implement and that their students thoroughly enjoyed participating in the hands-on activities. They especially liked the project-based lessons and the journal writing. Although some lessons require a fair amount of preparation, most materials can be reused in future lessons, making the preparation time for those lessons shorter. Recommendations by field testers and examples of students' work from the field testers were incorporated in the revised lessons. In addition, Bill Andrew, Director of the Office of Environmental Education in the California Department of Education (CDE), and Gary Smith, coordinator of several CDE environmental education projects, who was on leave from the Anaheim Joint Unified School District, reviewed these lessons. Also, over a dozen professionals in the integrated waste management field checked the "Background Information for the Teacher" and the "Appendixes" for technical accuracy.

Natasha Stillman for San Francisco's Solid Waste Management Program has reviewed the units and developed a solid waste jurisdiction-oriented information packet. This packet includes local information about the closest landfills; locations of recycling centers; available speakers; field trip opportunities; and classes, books, and videos available to teachers living in the San Francisco area. It is recommended that teachers contact staff from their local solid waste management agencies and encourage them to develop packets of information concerning integrated waste management in their communities. A template in "Appendix G" has been designed to help guide the teacher to acquire information about local integrated waste management coordinators, facilities, and practices. For a copy of San Francisco's Solid Waste Management Program information packet, contact Natasha Stillman, School Education Coordinator, at (415) 554-3422; or the California Integrated Waste Management Board's Office of Integrated Environmental Education at (916) 341-6769.

The staff at the California Integrated Waste Management Board's Office of Integrated Environmental Education is planning to provide staff development opportunities for teachers. For information, call (916) 341-6769.

It would be beneficial to those who use this curriculum if the staff at the California Integrated Waste Management Board were kept informed of teachers' experiences with the lessons. Any descriptions and photographs of projects that students complete and that are sent to CIWMB's Office of Integrated Environmental Education would be considered for the next edition of *Closing the Loop*.

<u>The address is:</u>

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K–3 Module

Introduction to the K-3 Module of *Closing the Loop: Exploring Integrated Waste Management and Resource Conservation*

The lessons in *Closing the Loop: Exploring Integrated Waste Management and Resource Conservation* encourage students to be positive role models by examining their waste management habits and by voluntarily participating in projects that improve their school and community. The lessons in *Closing the Loop* (*CTL*) create a laboratory of learning. Students learn concepts and explore issues concerning natural resources and integrated waste management and apply the concepts tohe world outside their school.

This unit was rated "number one" by a committee of teachers who evaluated nearly 100 curricular and activity guides for the 1999 edition of *Environmental Education Compendium for Integrated Waste Management and Used Oil*.

The K-3 Module of the 2000 edition of *Closing the Loop* is composed of five units. A tab on the right-hand side of each right-facing page identifies the module and unit number. Each of the first four units contains five lessons, and Unit 5 is made up of three lessons. The titles of the units are:

- Unit 1: Conserving Natural Resources
- Unit 2: Reducing, Reusing, and Recycling Classroom Waste
- Unit 3: Vermicomposting
- Unit 4: Proper Disposal of Waste
- Unit 5: Proper Management of Household Hazardous Waste

The overview of each unit contains the following components:

- The unit's concept(s)
- Each lesson's title, concept(s), and overview
- A book or a list of books required to implement each unit (and sometimes additional books recommended for the unit)
- Projects that students can do and examples of classes participating in specific projects

By using *CTL*, teachers will be following recommendations from California's newly adopted content standards and from curricular frameworks in a conceptual, interdisciplinary, and hands-on manner. If a teacher wishes to replace an activity described in *CTL* with another activity from another curricular guide, this can be done easily. However, it is important that the main concept of each lesson be preserved, or the lesson will no longer fulfill the intent of its original design.

The California State Board of Education's content standards from the following documents were used in the *CTL* lessons:

- *Science Content Standards, Grades K-12*, Pre-publication Version, August 26, 1999
- *English-Language Arts Content Standards for California Public Schools, Kindergarten Through Grade Twelve.* Sacramento: California Department of Education, 1998
- *Mathematics Content Standards for California Public Schools, Kindergarten Through Grade Twelve.* Sacramento: California Department of Education, 1999

Note that only a prepublication version of the Science Content Standards was available at the time that this curriculum was written. However, all cited science content standards have been adopted by the California State Board of Education.

The following state frameworks are also cited in the *CTL* lessons:

- *Science Framework for California Public Schools, Kindergarten Through Grade Twelve*, 1990
- *History-Social Science Framework for California Public Schools, Kindergarten Through Grade Twelve*, 1988
- *The Visual and Performing Arts Framework for California Public Schools, Kindergarten Through Grade Twelve*, 1996

It is recommended that Unit 1 on natural resources be taught first, so students can get background information on natural resources and why they are important and so that students can understand the connection between integrated waste management and the conservation of natural resources. This unit sets the stage for understanding why reducing, reusing, and recycling are so important.

Ideally, the five units in the K-3 Module should be taught in the order presented. Within the units, the lessons should also be taught in the order presented. However, it is understood that some teachers prefer to select lessons to incorporate in their curriculum; therefore, an attempt was made to make each lesson stand on its own (although sometimes connections to other lessons are suggested).

Each lesson provides step-by-step instructions on how to implement the activities in the lesson. More experienced teachers may choose not to follow this lengthier explanation of the activities. Instead, they can use the overview of each unit as an outline of what they will have their students do in each lesson. They might wish to develop their own activities with the lesson's concepts in mind. As needed, they can review the instructions specified in the lessons and use parts of these instructions when developing their own instructional strategies.

In the K-3 Module, it has been suggested that certain activities be conducted with children in kindergarten and first grade, while other activities will be more appropriate for older students in grades two and three. The teacher can best judge which activities will provide the most meaningful experiences for his or her students.

Whenever possible, the authors recommended that reused materials be used in the lessons. It is also important for teachers to model reducing, reusing, and recycling classroom materials, including buying products made from recycled materials. In most lessons, when teachers develop a list with their students, they have the option of writing the list on a chalkboard or on butcher paper. However, if a list needs to be kept and used again in future lessons, the butcher paper provides a more permanent alternative and eliminates the possibility that the contents will be erased. It is recommended that both sides of the butcher paper be used for writing, and then the paper can be used in art projects, composted (or vermicomposted), or recycled.

It is highly recommended that the teacher encourage students to participate in a variety of projects. A project is a task or problem that usually groups of students work on to supplement and apply what they have learned in the classroom. Allow students to plan and design their projects.

In this curriculum students have opportunities to engage in many different types of projects. Some projects are relatively simple, such as making note cards out of recycled paper to give as gifts or decorating cardboard boxes for gathering items that can be reused in the classroom and for those that can be recycled. Other projects are much more involved, such as maintaining a vermicomposting bin in the classroom or presenting a play to other classes about the importance of natural resources. And still others will take large amounts of time and dedication, such as planting seedlings, shrubs, and wildflowers on the school campus or in a nearby park or participating in a coastal cleanup of litter.

Examples of projects and classes participating in some of the projects are listed in the "Overview" for each unit. For more information on project-based learning, see "Tips for Implementing Projects." Also, the Autodesk Foundation provides information for educators interested in project-based learning. The Foundation's website is http://www.autodesk.com/foundation.

Make public what your class is doing when implementing *Closing the Loop* and publicize some of its recommended projects. Have students design presentation panels, submit photographs and news articles to local newspapers, tape conversations with students about their projects, videotape brainstorming sessions, and show students' work during the school's open house.

LESSON 1: What Are Natural Resources?

LESSON'S CONCEPT

Natural resources are things that come from nature, such as plants, animals, soil, minerals, energy sources (e.g., sunlight, fossil fuels), air, and water. These natural resources are used to meet the needs of all living things, including people.

PURPOSE

Students will learn about natural resources and the products people make from these resources. Students also prepare for the unit by making journals.

OVERVIEW

In this lesson students will:

• Make journals.

• Observe models of categories of natural resources.

• Identify natural resources on the school grounds, record them on a chart, and describe them in their journals.

• Determine natural resources used to make various items on the school grounds and in the classroom.

• Compare items made from different natural resources.

CORRELATIONS TO CALIFORNIA'S CONTENT STANDARDS AND FRAMEWORKS

• Students work together to identify the natural resources used to make objects outside and inside the classroom.

- "Properties of materials can be observed, measured, and predicted. As a basis for understanding this concept, students know: objects can be described in terms of the materials they are made of and their physical properties." (*Science Content Standards, Grades K–12*; Kindergarten; Physical Science, Standard 1a)

- "Humans use air, fresh water, soil, minerals, fossil fuels, and other sources of energy that comes from the Earth. " (*Science Framework*, page 97)

- "Students collect information about objects and events in their environment." (*The California Mathematics Academic Content Standards for Grades K–12*; Kindergarten; Statistics, Data Analysis and Probability, Standard 1)

- "To participate effectively in society, students need to: Develop personal skills. . . group interaction skills (and). . . social and political participation skills." (*History–Social Science Framework*, page 24)

• Students describe in their journals some natural resources outside and inside of the classroom and determine the natural resources used to make certain products. ("Using the Grade 1 writing strategies outlined in the previous standard, students write brief descriptions of a real object, person, place, or event using sensory details." *California Language Arts: Reading, Writing, Listening, and Speaking Content Standards for Grades K–12*; Grade 1; Writing Applications, Standard 2.2)

SCIENTIFIC THINKING PROCESSES:

observing, communicating, comparing, classifying

TIME:

45–60 minutes to prepare for the lesson; 60 minutes to implement the lesson

VOCABULARY:

crude oil, fossil fuels, icon, minerals, natural resources, organisms

PREPARATION

___**1.** Read the "Background Information for the Teacher" at the end of this lesson.

___**2.** Obtain used paper (blank on one side) for students to use for journals. (Sources of used paper include printers, real estate offices, school's office or classrooms, and parents.)

___**3.** Start collecting "clean" classroom trash to use for Lesson 3 (nothing toxic or potentially dangerous; no food that can get spoiled). Keep it in a box or bag. Make sure to notify the custodian of your plan. Try to include paper towels, candy wrappers, short pencils, small pieces of chalk, bent paper clips, paper used on one side and used on both sides, aluminum can or tray, plastic container, milk carton, polystyrene meat tray, dried-up markers and glue sticks, nuts with hard shells, and fresh orange peels.

___**4.** Make a copy of the "Natural Resources Chart" for each pair of students. (page L1–8-x)

MATERIALS

___ Items that can represent different categories of natural resources:

- ___Potted plant (to represent trees and other plants)
- ___Stuffed animal (to represent animals)
- ___Bag of soil (to represent soil)
- ___Rock (to represent minerals)
- ___Molasses or chocolate syrup (to represent crude oil, a fossil fuel which is an energy source)
- ___Empty jar and a jar full of water (to represent air and water)

___ A pocket folder for each student (If you plan to have students make their own journals, see "One Way to Make Your Own Journal" in this lesson.)

___ A copy of the "Natural Resources Chart" for each pair of students

___ Clipboard (Heavy cardboard cut to 9" x 12" can be used as a clipboard, and a large paper clip can keep the paper on the cardboard.)

___ A file folder for each student for the "Assess ment Portfolio" (If possible, use reused ones or those made from recycled materials.)

___ Optional: a file box to keep the "Assessment Portfolios"

PRE-ACTIVITY QUESTIONS

A. Tell students that they will each make a journal. In the journal they will write and draw information about what they are study ing. Students should know that people write and draw in journals to record observations, thoughts, ideas, and information about certain topics.

B. Provide a pocket folder and ten sheets of paper to each student. (If you do not have access to pocket folders, students can make their own folders by following the directions on "One Way to Make Your Own Journal.") To model conserving paper, distribute paper that was used on one side.

C. Ask students to draw or describe in their journals something that comes from nature.

D. Ask students to share the entries from their journals as you write their responses on the chalkboard.

E. Ask students what they know about the word *natural* and the word *resources*. Encourage them to create a class definition of *natural resources.*

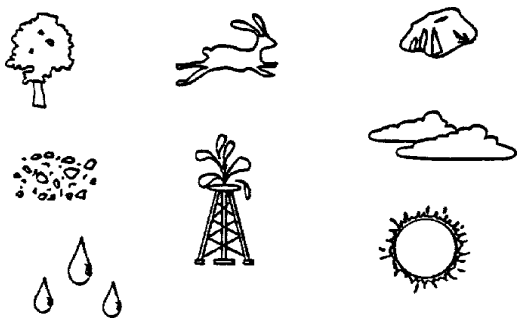
PROCEDURE

A. Show the following items, each representing a category of natural resources: potted plant, stuffed animal, soil, rock, and molasses (to represent crude oil, an energy source).

- Tell students that things that come from nature are called *natural resources.* Natural resources are things that all living things need in order to live.

- Help students identify each category of natural resources as you list them on the chalkboard: plants, animals, soil, minerals (rocks), energy sources (sunlight; fossil fuels, such as crude oil).
- Ask students what else they can't live without. Lead them to say "water" and "air."

B. Ask students to draw an icon for each of the seven categories of natural resources. (Note: Help them write a definition for icon and include it in their journals.) This can be done in groups of seven, with each student drawing one icon and writing the category that the icon represents. (See the example below for ideas for icons.)



C. Provide a copy of the "Natural Resources Chart" for each pair of students. Note that students will focus on five categories of natural resources, because these are the ones most often used by people to make things (in addition to air and water, which we usually use in the manufacturing process of products): plants, animals, soil, minerals, and crude oil (from fossil fuels in the category of energy sources).

- Describe how to complete the chart. Students should write or draw what they see that comes from the natural resources listed on their charts.
- In preparation for a trip outside the classroom, ask each pair of students to bring a "Natural Resources Chart," pencil, and a clipboard. (A clipboard can be made out of stiff cardboard.)
- Lead students outside.

Note: The answers in *italics* are possible students' answers and might not reflect a correct answer.

- Help students identify things that are part of nature. *Trees, rocks, soil.*
- Ask them what natural resources they see (or feel, in the case of air). *Plants, animals (people), minerals, crude oil (asphalt), air*
- Ask students what they see that people have made from natural resources. For example, "What do you see that is made from a plant?" *A wooden bench is made from wood from a plant.* "What do you see that is made from minerals, such as rocks and steel?" *The building, the road, the poles supporting the swing.*
- Select one item on the school grounds and help students complete their charts.
- Lead students on a walk on the school grounds to look for natural resources and help them to complete their charts.

D. Back in the classroom, ask students to write or draw the following in their journals:

1. I saw _____
2. _____ is part of nature.
3. One thing that I saw that was made by people is _____
4. The natural resource or resources from which this thing was made is _____

E. Ask students to share their journal entries. Then discuss some ways that natural resources are used by people.

DISCUSSION/QUESTIONS

A. Have students locate in the classroom objects made from natural resources. Ask students from which category of natural resources this object was made.

B. Ask students to review their original class definition of natural resources and ask whether they wish to change any of the words to make the meaning more clear and accurate.

C. Discuss with students:

- Which items that were seen indoors and outdoors were different but came from the same natural resource? *Buildings and the sidewalk; desks and bench*
- Which items that were seen indoors and outdoors were similar but came from different natural resources? *Wooden bench and plastic bench*

Note: In Lesson 2, students will learn more about ways people use natural resources.

APPLICATION

A. As a class, make a drawing (mural) linking an item in the classroom to the natural resource that was used to make this item; e.g., wooden chair—plant.

B. Ask students to draw or write in their journals what they learned about natural resources.

C. Ask students to share their journal entries.

Homework Assignment: Ask students to select an item at home and to be prepared to tell the class the following day what the item is and what natural resource or resources it came from.

D. Ask students to share their homework assignment.

E. In addition to journals, it is recommended that students make an "Assessment Portfolio" to keep samples of their work from each lesson or unit. This will provide an authentic assessment of performance-based student work.

1. Introduce the idea of a portfolio. Explain that a portfolio contains information that illustrates a student's work. Discuss the following reasons for a student to select items to be placed in a portfolio:

- It is the student's best work during the lesson or unit.
- It represents something that the student learned.
- It represents something that was chal lenging to the student.
- It is something that took a long time and effort to complete.
- It was something the student greatly improved upon. (The student could submit "before" and "after" examples of work.)

2. Provide a file folder to each student.

- Ask each student to write his or her name on the tab of the file folder. (You might need to help the younger students with this task.)
- Ask students to select products (drawings or writings) from their journals.
- Have students answer the following questions verbally about the work they selected (could be shared with the class if the students agree to do so):
  - Why did you choose this piece to include in your portfolio?
  - Why is this your best work (drawing, writing, project)?
  - What did you learn from this work?
  - If you ever did this project (or other work) again, what would you do differently?

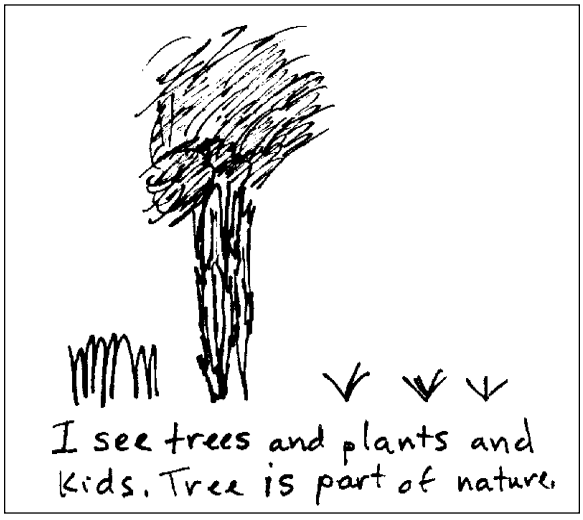
Note: It is recommended that a file box be provided to keep the students' "Assessment Portfolios."

Note: Students can select examples of work from their journals and from any projects that they completed at the end of each lesson. Or, instead of selecting a product from each lesson, students can select one or two from the entire unit, once the unit has been completed.

EXTENSION

Make a class list of things in the room according to the natural resources from which they were made. Graph things in the room by categories of natural resources. Discuss:

- What is the most common natural resource used in the classroom?
- Why is it the most common natural resource used?



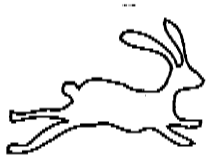
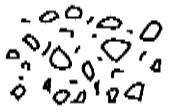
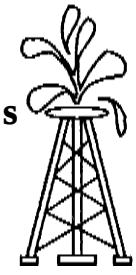
Submitted by Beth O'Neal, kindergarten and first-grade teacher, Marguerite Hahn Elementary School, Cotati–Rohnert Park Unified School District.

Submitted by Debby Carter, kindergarten and first-grade teacher, Coyote Valley Elementary School, Middletown Unified School District.

Student's Page

Natural Resources Chart

Names: _____ **Date:** _____

Natural resource	Object made by people
Plants 	
Animals 	
Soil 	
Minerals 	
Energy sources (fossil fuels, like crude oil) 	

ONE WAY TO MAKE YOUR OWN JOURNAL

SUPPLIES NEEDED

___ 12" X 18" tagboard or construction paper (two sheets for each student)

___ Stapler

___ Three-hole paper punch and brass fasteners (three for each student). If these are not available, the pages can be stapled.

___ Lined and unlined paper (15 sheets per student: 5 lined and 10 unlined)To model reusing, use paper that has been used on one side.

DIRECTIONS

1. Distribute two sheets of 12" X 18" tagboard or construction paper to each student.

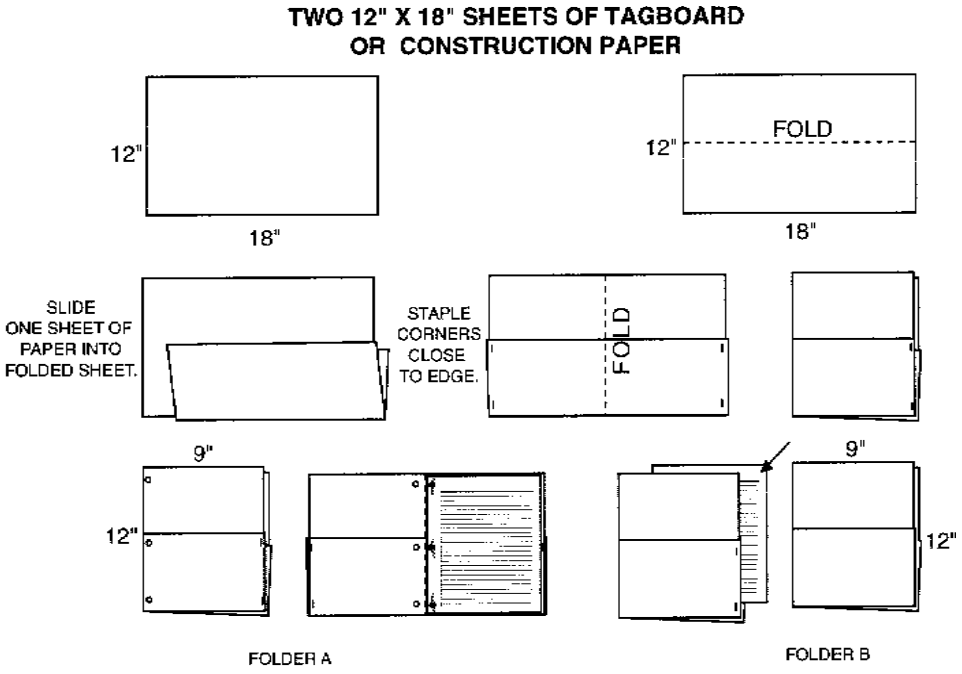
2. Have students make their journals by doing the following (see illustrations below):

- Fold one sheet of tagboard or construction paper in half lengthwise.
- Slide one sheet of paper into the folded sheet.
- With the folder open, staple the left side and the right side of the folded sheet onto the unfolded sheet, as close to the edge as possible. The folded sheet will make pockets on the inside and outside of the front cover.
- Fold the entire journal cover in half so it closes like a book.

3. **A.** If you have brass brads, punch three holes in the left margin with a three-hole punch. (See Folder A.) Place the brass fasteners through the back of the folder and through the lined and unlined pages but not through the front cover. This will make the front cover easier to open.

B. If you do not have brass brads, staple the journal pages to the journal cover.

(See Folder B.)



BACKGROUND INFORMATION FOR THE TEACHER

Natural resources are things that come from nature (the natural environment) and are the living and nonliving components that support life on Earth. They can be classified into seven categories: plants, animals, soil, minerals, energy sources (e.g., sunlight, fossil fuels), air, and water.

All products that we use everyday come from Earth's natural resources, which provide the raw material for the products that people make. For example, iron ore is the raw material in the natural resources category, mineral, and people use iron ore to make steel. Steel is used to make cars, appliances, and many other products. Trees are natural resources classified as plants, and people use trees for lumber to build houses and other structures; they also use a tree's pulp to make paper.

This unit introduces students to different categories of natural resources and ways some natural resources are used by people to make a variety of products (which often end up in a landfill). Since natural resources are required by all living things, humans are also totally dependent on natural resources, such as air, water, plants, and animals, for their survival.

In this unit, natural resources are classified into seven categories, which are briefly described below. The category of energy sources can be further subdivided into sunlight, fossil fuels, and other energy sources (e.g., wind, hydropower). Ways that people depend on these categories of natural resources are further described in Lesson 2.

PLANTS—Plants are living things that can produce their own food. Trees, shrubs, grasses, seaweed, and some microscopic algae are examples of plants. Green plants produce oxygen. They also produce food for animals that eat plants.

ANIMALS—Most animals can be defined as living things that rely on other organisms for food. Animals have a nervous system and can usually move on their own. Examples of types of animals are: mammals (includes humans), birds, reptiles, amphibians, fish, and invertebrates, such as insects, spiders, and worms. Some microscopic living things are also classified as animals.

SOIL—Soil is a mixture of minerals from weathered rock and decaying plant and animal matter. It also consists of microscopic living things, such as bacteria and fungi. Most plants that live on land need soil in which to grow, and soil provides water and nutrients to plants. Many animals live on or in soil.

MINERALS—Minerals are naturally occurring substances that originally came from rock, such as phosphorous, bauxite, iron, salt, gold, silver, copper, and potassium. Many minerals are essential for the healthy growth of plants and animals, and plants absorb minerals that are dissolved in water. Animals must obtain needed minerals by eating plants or by eating other animals that have eaten plants

AIR—Animals need oxygen in air to breathe, and plants use carbon dioxide in air in the process of photosynthesis. The gases are recycled through plants and animals.

WATER—Plants use water when manufacturing their food, and animals drink or absorb water to maintain bodily functions. Some animals live in water, and some use it as a place from which to get food, to seek protection, or to cool off. Fresh water on land is replenished by the water cycle and is essential to all living things.

ENERGY SOURCES

• **Sunlight**—The energy derived from sunlight is used by green plants for photosynthesis. Sunlight also powers the water cycle by evaporating water from land and surface water. Note that "sunlight" is not addressed in this unit, because the lessons focus on the connections among natural resources, manufactured items, and solid waste.

• **Fossil Fuels**—Fossil fuels include crude oil, coal, and natural gas. The fossil fuels we are using now originated from partially decayed plants and animals that lived millions of years ago. In this unit students are introduced to crude oil. The crude oil that we are presently using came from marine plankton that lived millions of years ago. These marine plants died, and through time and tremendous pressure and heat created by layers of rock that trapped the plants, crude oil was formed.

- **Other Energy Sources**—Other energy sources include wind, hydropower, geothermal, and tidal energy. These are not addressed in *Closing the Loop*.

Note: For information and activities on renewable and nonrenewable natural resources, see 4–6 Module, Unit 1, Lesson 4.

At the Solar Community Housing Association, Homestead CO-OP, children look for examples of natural resources and objects that people made from natural resources.

NOTES

LESSON 4: Making Recycled Paper by Hand

LESSON'S CONCEPTS

- Waste paper can be made into recycled paper in order to conserve trees and space in landfills.
- Buying products made from recycled materials continues a cycle that conserves natural resources.

PURPOSE

Students will learn how to make recycled paper. Students will also identify how buying recycled products "closes the loop."

OVERVIEW

In this lesson students will:

- Listen to descriptions and conclude that most paper is made from trees.
- Observe various types of paper with a magnifying lens.
- Use various steps involved in recycling wastepaper by making their own recycled paper in the classroom.
- Make planters out of recycled paper and plant seeds or seedlings.
- Look for the symbol on products that indicates the product is made from recycled material.
- Discuss how "closing the loop" benefits the environment and people.

CORRELATIONS TO CALIFORNIA'S CONTENT STANDARDS AND FRAMEWORKS AND TO THE BENCHMARKS FOR SCIENCE LITERACY

- Students compare similarities and differences in types of paper, including those made from recycled fibers, after they observe these with a magnifying lens.
  - "Magnifiers help people see things they could not see without them." (*Benchmarks for Science Literacy*, page 111)
- Students work in groups to make recycled paper. They read directions.
  - "Many materials can be recycled and used again, sometimes in different forms." (*Benchmarks for Science Literacy*, page 119)
  - "Several steps are usually involved in making things." (*Benchmarks for Science Literacy*, page 188)
  - "To participate effectively in society, students need to: Develop personal skills . . . group interaction skills . . . (and) social and political participation skills." (*History–Social Science Framework*, page 24)
  - "Students know about letters, words, and sounds, and they apply their knowledge in reading simple sentences." (*California Language Arts: Reading, Writing, Listening, and Speaking Content Standards for Grades K–12*; Kindergarten; Reading: Word Analysis, Fluency, and Systematic Vocabulary Development, Standard 1.0)
  - "Students create original artworks based on personal experiences or responses." (*Visual and Performing Arts Framework;* Visual Art: Creative Expression Component, Goal 4, page 101)
- Students draw and write descriptions of how to make recycled paper.
  - "Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept . . . students will: draw pictures that correctly portray at least some features of the thing being described." (*Science Content Standards, Grades K–12*; Grade 1; Investigation and Experimentation, Standard 4a)

- ". . . write or draw descriptions of a sequence of steps, events, and observations." (*Science Content Standards, Grades K–12*; Grade 2; Investigation and Experimentation, Standard 4d)

SCIENTIFIC THINKING PROCESSES:

observing, communicating, comparing, ordering

TIME:

60 minutes to prepare for the lesson and to prepare the paper pulp; 45–60 minutes per day for two days to implement the lesson, plus 30 minutes three days later (or whenever the recycled paper in the planter is dry) to plant seeds

VOCABULARY:

"closing the loop," conserve, pulp, pulp slurry, virgin paper

PREPARATION

Note: It is recommended that only "Part I-A, Making a Paper Planter" be completed by students in kindergarten and grade one; and both "Part I-A, Making a Paper Planter" and "Part I-B, Making Recycled Paper" be completed with students in grades two and three.

____**1.** Read the "Background Information for the Teacher" at the end of this lesson.

____**2.** The day before you plan to do this lesson, have each student prepare to make a paper planter by tearing two full pages of newspaper into one-half to one inch pieces. Fill buckets or pans with one part newspaper pieces and three parts water. Let the mixture sit overnight. The newspaper pieces will be soft and ready to be pulped the next morning.

Note: By soaking the mixture overnight, a blender will not be needed for making the paper planter. Then the blender can be used solely for the activity of making recycled paper. For younger students (in kindergarten and first grade), a blender will not be necessary, and you will not need to complete "Preparation" #2 and 3.

____**3.** Either make one transparency of, or make a copy and consider laminating, "Steps to Make Recycled Paper" (page L4–14x). (If you are using two blenders, you will need to make two copies of the "Steps.")

____**4.** Make a transparency of "Closing the Loop: The Meaning of Recycling Symbols" (page L4–16x).

____**5.** Obtain enough window screen to cut several rectangles, approximately 8 inches by 10 inches. Most hardware stores will donate pieces of old screen. You can also buy a roll and share with other teachers. Cut the window screen into rectangles approximately 8 inches by 10 inches. (Larger or smaller sizes of screen can also be used.) Place duct tape around the cut screen to cover rough edges and to make the edges stiffer. If you have access to half-inch wood strips to use for framing the screen, staple the screen onto the wood.

MATERIALS

For "Pre-Activity Questions"

____The book *Be a Friend to Trees* by Patricia Lauber or a similar book that describes the fact that trees are cut and their wood pulp is used to make paper

____Sample of various paper, some of which is made from recycled fibers (for example: chipboard (cereal box), made from recycled fibers; magazine (coated with clay); newsprint (most newspapers will note their paper has recycled content); white office paper (if available, obtain some made from recycled fibers); construction paper. Also if available, provide an example of recycled paper made by students.

____Magnifying lens (one for each pair of students)

____If available, a microscope

For "Part I-A, Making a Paper Planter"

____Small milk cartons (6-ounce size), rinsed and top cut out; or yogurt containers, one for each student

____A few stacks of newspapers

____Seeds to plant in the paper planter. Some nurseries will donate seeds. Consider planting native wildflowers or radishes (that students could eat).

____Approximately one cup of soil for each paper planter

For "Part I-B, Making Recycled Paper"

____Several 8 inch by 10 inch pieces of window screen

____Duct tape or wooden frames for each screen

____Scissors

____Two or more two-gallon plastic dishpans

____Two or more large slotted spoons (depending on the number of dishpans)

____One or two blenders (to speed up the process, obtain a ratio of one blender for up to three plastic dishpans)

____A copy of "Steps to Make Recycled Paper" for each blender

____Scraps of white and colored paper

____Several towels or sponges (or additional newspaper for removing excess water)

Note: If students plan to write on their recycled paper, consider adding some liquid fabric starch to keep the ink from spreading.

Optional:

____An embroidery hoop, a wooden picture frame, large cookie cutters, and/or a coffee can (with both ends removed) to be used as frames for a screen

____Leaves, flowers, potpourri, and/or food coloring (to add to the recycled paper that students are making)

For "Part II, Buying Recycled Products"

____An example of the symbol that indicates that a product is made from recycled material from a cereal box or other product

____The transparency, "Closing the Loop: The Meaning of Recycling Symbols" found on page 70

Optional:

____The video, *Kids Talking Trash*

____A video on how paper is made (see "Resources)

For "Application"

____The book *Where Does the Garbage Go?* by Paul Showers

PRE-ACTIVITY QUESTIONS

A. The day before making the paper planter, soak a mixture of newspaper and water overnight. (See "Preparation #1.") Discuss what will happen to the newspaper that is soaked overnight. *The paper will break up; it will turn white; it will turn "mushy"; its ink will get in the water.*

B. Read to students pages 5–10 and 30–32 from the book *Be a Friend to Trees* by Patricia Lauber (could be substituted by another book on the same topic). Discuss:

- From what material is most paper made? *Wood* What category of natural resources is wood? *Plants* (Students learned this in the K–3 Module, Unit 1.)
- What are some other ways that plants are important? *They provide food and shelter to wildlife; people eat plants; people use wood from trees for lumber to build houses and furniture.*
- Who and what depends on trees and other plants to survive? *people, wildlife*
- What can we do to conserve (use fewer or avoid wasteful use of) trees? *Use fewer things made from trees; reuse things made from trees; recycle things made from trees.*

C. Provide samples of pieces of paper made from recycled fibers and from non-recycled fibers (virgin materials).

- Distribute magnifying lenses.
- Have students examine the various types of paper with their magnifying lenses to identify similarities and differences.
- If available, allow students to view paper fibers through a microscope.

D. Discuss with students:

- What do you see when you look at the paper through a magnifying glass? *Bits of stuff; fibers*
- What differences did you see between paper made with recycled fibers and non-recycled fibers? *You can see the recycled pieces in the recycled paper.*
- How do you know if something is made from recycled materials? *It says so on the box.* (This information is usually printed on the box or container and includes the three-arrow symbol. See example in "Part II.")
- What insect makes paper? *The paper wasp*

PROCEDURE

A. For "Part I-A, Making a Paper Planter" and "Part I-B, Making Recycled Paper" do the following:

- Separate the class into groups of three or four students.
- Two groups will make recycled paper,

while all other groups will be making paper planters.
- If you have two blenders, you can have four groups work on the recycled paper while the other groups work on their paper planters.
- Students who complete their planter can cut and/or tear scrap paper into a container while waiting their turn to make the recycled paper.

Part I-A, Making a Paper Planter

Note: The mixture for the paper planter was to be prepared the day before.

B. Provide newspapers (to be spread in the work area), a small milk carton (with the top cut) or yogurt container for each group.

Note: For younger students you will need to demonstrate how to make a paper planter.

1. Stir the pulp mixture (which has been soaking overnight) in each bucket or pan until it looks like mush. (Soaking and stirring breaks the fibers down into a form that can be bonded together again to form recycled paper.)

2. Have students:
- Take a handful of the pulp mixture. (They should squeeze as much water out of the pulp as possible back into the bucket or dishpan.)
- Use dry pieces of newspaper to remove the excess water. (This step is very important, or the paper planter will take too long to dry.)
- Use a small milk carton or other container and mold the pulp inside the carton. The pulp should be about one-fourth inch thick.
- Use additional pieces of newspaper to remove the excess water inside the paper mold.

C. Allow the planters to dry completely (about three days) inside the carton. You might set these out in the sunlight for a few hours each day.

Once the paper planters are dry:
- Take the handmade paper planters out of the milk cartons. The milk cartons can be reused or also used as planters.
- Provide soil and plant seeds in the planters. If the seeds are from native wildflowers, once they mature, students can take these home or plant them on the school grounds. If radish seeds were planted, students can wait until the radishes are large enough to eat. Then a salad that includes the radishes can be made for the whole class.

Students from Lynda Mooney's first-grade class at Las Palmas Elementary School show their paper planter and paper made from recycled fibers.

Note: When planting the seedlings, place the entire paper planter with the plant in the ground. The paper planter will decompose.

Project Idea: With the class, plant seedlings, shrubs, and/or wildflowers on the school campus or in a nearby park. The U.S. Forest Service, the California Department of Forestry, and some timber companies and nurseries will often donate to schools seedlings from native trees and other plants. If seedlings are to be planted on the school grounds or in other parts of the community, it is recommended that the species of the seedlings be appropriate for the existing soil and weather conditions where they will be planted. This will ensure a greater survival rate for the plants.

Part I-B, Making Recycled Paper

Note: For younger students, prepare the pulp slurry in advance. For safety reasons, do not allow younger students to work the blender.

Note: Use white and colored scrap paper to make colorful recycled paper. Adding potpourri (be careful not to use potpourri that has soap in

Students in Betsy Weiss's first-grade class at Paden Elementary School work in groups to make recycled paper.

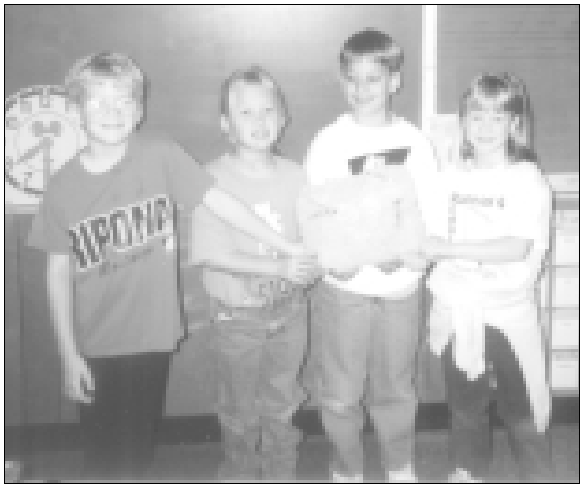
the fragrances because it will make the pulp sudsy), spices, and / or flowers prior to blending the paper will give you the recycled paper texture and scent. You can also use newspaper from which to make recycled paper; then add colored paper, streamers, food coloring, or berries to give you colored recycled paper, although the recycled paper will have a grayish hue.

D. Set a copy of "Steps to Make Recycled Paper" by each blender. While the rest of the class members are molding their paper planters, teach the first two groups how to make a recycled sheet of paper. They should follow the directions on "Steps to Make Recycled Paper." (If you have two blenders, then teach four groups.) When students from the first two groups have completed making the paper, have them teach the students in the next two groups how to make the paper. Then the members of the first group can work on their paper planters. The second group will teach the third group and so on. (Again, if there are two blenders, you can have two groups teach two other groups.)

Note: Adding liquid fabric starch to the pulp will allow students to write in ink on the recycled paper without the ink spreading.

E. Have students use a magnifying lens or microscope to examine the recycled paper that they made.

Note: Keep one paper planter and one milk carton to test for speed of decomposition in the K–3 Module, Unit 3.



Students from Ted Schut's first-grade class at Ripona Elementary School show the recycled paper that they had made.

Project Idea: Have students make cards (e.g., for Mother's Day or Father's Day, birthdays, notes) out of recycled paper to give as gifts. Some could be sold for fund-raising purposes.

Part II, Buying Recycled Products

A. Show students an example of the symbol that indicates that a product is made from recycled material. Consider showing a section of the video *Kids Talking Trash* that explains how to read a package to determine whether it is made from recycled material.

B. Project the transparency "Closing the Loop: The Meaning of Recycling Symbols" and ask students, "If you put paper in the recycling bin represented by the first arrow in the logo for recycled material, and the second arrow represents the making of new paper, what do you think the third arrow means?" *Buying products made from recycled paper.* (You will probably need to lead students through this thought process.)

1. Ask:

- How do you think this "closes the loop"? *The paper doesn't get thrown away into a landfill; it gets made into new paper.*

- How do we make sure we are "closing the loop"? *Reuse paper; then recycle it to be made into new paper; then buy products made from recycled materials.*

2. Explain that "closing the loop" is practicing all of the three activities depicted in the recycling loop (i.e., collecting, manufacturing, and buying recycled material). Without any one of those activities, the loop remains open. And if you are not buying recycled products, you are not completing the recycling process.

C. If available, show students a video, photographs, or books with photographs about manufacturing recycled paper.

Homework Assignment: Ask students to look on packaged items for the symbol that indicates that a product is made from recycled material. Then have them list or draw at least two products that contain the recycled content symbol to share with the class the following day. They can bring a box with the symbol or cut the symbol from the box. (***Safety Note***: Students should request the assistance of an adult to cut the symbol from the box.)

DISCUSSION/QUESTIONS

Discuss with students:

- What does the word *conserve* mean? *To keep from wasting; to save*
- How does recycling paper conserve trees? *Fewer trees are needed to make paper because we are using and buying less paper.*
- How does recycling paper conserve landfill space? *Less paper goes into the landfill so it will take longer to fill up.* Inform students that, in California, paper makes up 31 percent of the residential (household) waste stream.
- How does buying or making recycled paper conserve trees and landfill space? *To make recycled paper, less tree pulp is used and less paper is being thrown into the landfill, because the paper is being recycled and used again.*
- Why is it important to buy products made from recycled materials? *Trees are conserved and so is landfill space.*

APPLICATION

A. Have students determine how the recycled paper they made could be used; e.g., as a greeting card, for a sign. Then ask them to use the recycled paper they made for a specific purpose.

B. The following should be discussed with older students:

- Describe what "closing the loop" means. *Placing recyclable items into a bin for collection, having the manufacturing companies make new items with the recycled product, and buying recycled products.*
- How does "closing the loop," by buying recycled materials, conserve natural resources? *Fewer natural resources are needed to make things from recycled materials (e.g., recycled paper) than it takes when those same things are made from raw materials (e.g., tree pulp).*
- How does "closing the loop" benefit people and the environment?

C. As a class, make a list of the benefits of recycling paper and using recycled paper, and share the information with another class. Also list the benefits of reusing paper.

D. Show students page 24 in the book *Where Does the Garbage Go?* by Paul Showers. Have students compare the papermaking steps they used with those used by the paper mills in the manufacture of recycled paper. Or have students use pictures, labels, and short phrases to create a poster describing the benefits of recycling paper.

E. Ask students to draw and write descriptions of the sequence of steps of how to make recycled paper.

Project Idea: Encourage students to come up with ways to demonstrate that recycled paper (made from recycled paper fibers) can be as good as virgin paper (made from wood pulp). They can test for strength, color, absorption. Have students summarize their results in a chart. This chart can be used to encourage students, parents, and school staff to buy recycled products.

EXTENSIONS

A. For more sophisticated methods of making paper in the classroom, see chapters 4–10 in Arnold E. Grummer's book *Paper by Kids*, as well as other references listed in the "Resources" section. You can assign groups of students to try some of the paper

variations described in chapters 6–8 in *Paper by Kids*. These include making decorative paper using thread, leaves, dried flower pieces, and dyes.

B. Have students select colors of paper from which to make recycled paper and to predict the final color the color blends will produce.

C. Allow the paper in the recycle bin to stack up for a week or two. Let the children guess how far the stack will grow. Mark their predictions on a chart. Repeat this activity throughout the year; make it a goal to reduce the size of the stack.

D. Keep track of how many pounds of paper you recycle in the classroom in one month. Make a chart and post it beside your class's recycling bin. How many pounds of paper was saved? How many could the whole school save? (Each ton of paper replaces and preserves about 90 tons of wood from trees.)

Note: It is difficult to calculate the number of trees this represents, because the size and type of trees used for paper vary.

E. Have a student conduct research on the paper wasp.

F. Have students find information on the history of paper and make a report to the class. (See "A History of Paper" in the "Appendix.")

RESOURCES

Video

Recycling: The Endless Circle. Washington, D.C.: National Geographic, 1992 (25 minutes).

Explains how recycling returns used materials to make new products, therefore reducing waste. The processes involved in recycling paper, aluminum, and plastic are described.

Books

Davis, Wendy. *From Tree to Paper*. Littleton, Mass.: scholastic, 1995

Describes the steps for manufacturing paper.

Brandt, Keith. *Discovering Trees*. Mahwah, N. J.: Troll Communications, 1982.

Describes the importance of trees.

Grummer, Arnold E. *Paper by Kids.* Minneapolis, Minn.: Dillon Press, Inc., 1980.

Describes a variety of ways that children can make recycled paper.

Lauber, Patricia. *Be a Friend to Trees.* New York: HarperCollins Children's Books, 1994.

Describes the importance of trees (food and habitat for animals, oxygen), including ways trees are used by people (for wood, paper).

Showers, Paul. *Where Does the Garbage Go?* Let's-Read-and-Find-Out Science series. New York: HarperCollins Children's Books, 1994.

Describes how materials can be recycled into new products.

Toale, Bernard. *The Art of Papermaking.* Worcester, Mass.: Davis Publications, 1983.

Describes various papermaking techniques.

Udry, Janice May. *A Tree Is Nice*. New York: Harper and Row, 1956.

Describes ways trees are important.

Weidenmuller, Ralf. *Papermaking: The Art and Craft of Handmade Paper.* Translated by John Kalish. San Diego, Calif.: International, 1984.

Describes various papermaking techniques.

Magazines

Powell, Jerry. "Hand Papermaking: Recycling Education at Its Best." *Resource Recycling*, (Jan./Feb., 1989), pp. 30-33 and 49.

This issue describes how to make recycled paper.

The Story Kids F.A.C.E., Illustrated. Nashville, Tenn. Vol. 8, Issue 2, (February/March, 1997). 1-800-952-3223; kidsface@mindspring.com

This issue describes how to make recycled paper.

Website

The Technical Association for the Pulp and Paper Industry (TAPPI) has information about paper and paper making. TAPPI's web site is: http://www.tappi.org.

STEPS TO MAKE RECYCLED PAPER

1. Place torn up paper in a blender until the blender is half full.

2. Cover the paper with water. The ratio is usually one part paper to two parts water. If the paper is not blending easily, you may need to add more water.

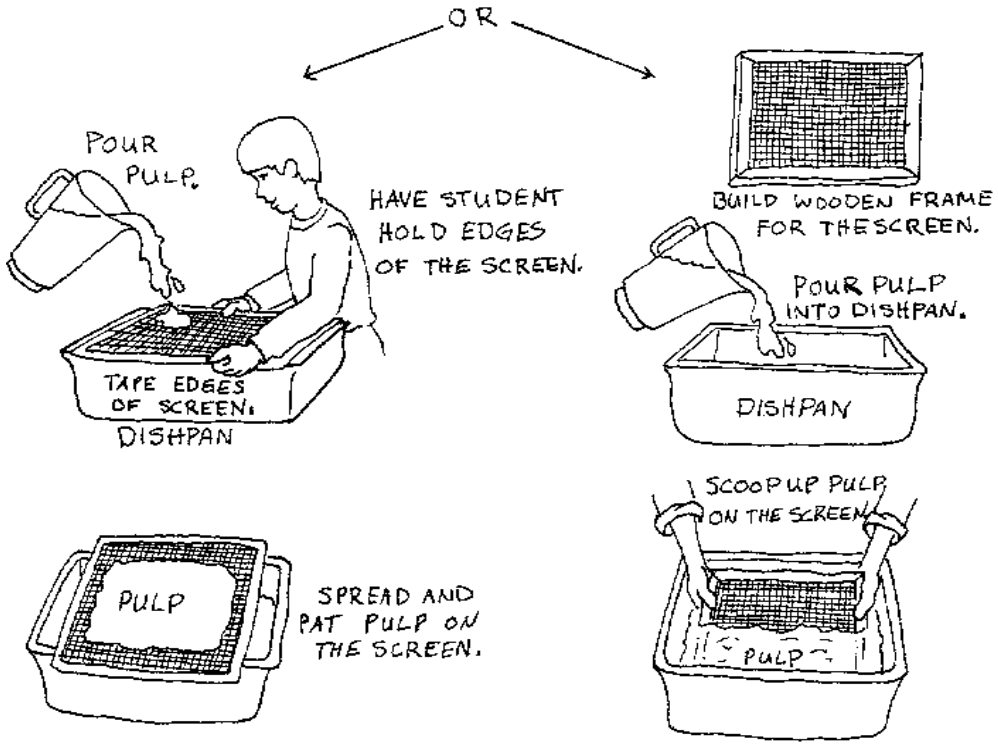
3. Blend until the paper has been ground into a slightly runny oatmeal-like consistency. Make sure it is not too thick. This mixture is called pulp slurry.

4. If the screen has a frame, pour the pulp slurry into a dish pan. Scoop the pulp with the screen. Spread and pat the pulp on the screen.

5. If the screen does not have a frame, one student should hold the screen taut over an empty dish pan while another student pours the pulp slurry from the blender over the screen. The water should drain through the screen, into the dish pan. Spread and pat the pulp on the screen.

6. Place a couple of pieces of newspaper in the working area and place the screen and pulp on top of them.

Optional: Press items, such as flowers, leaves, tissue paper, berries, into the recycled paper.

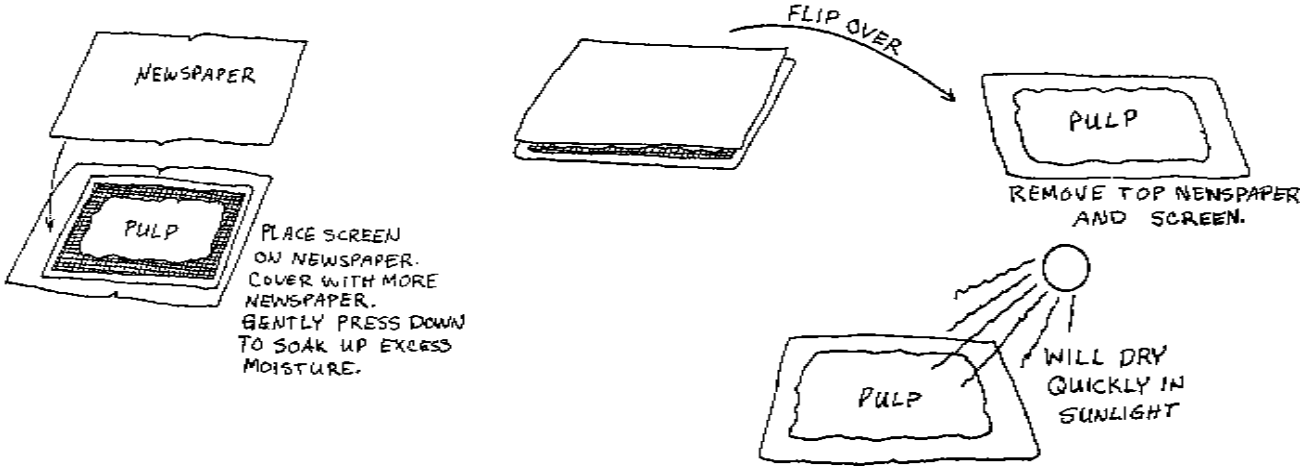


7. Use a couple of pages of newspaper and gently press down on the paper to soak up the excess water or use dishtowels (because the newspaper could leave black ink on white recycled paper).

Note: If the paper is pressed too hard, the pulp will separate. At this point you can patch up the holes. Or remove the pulp, roll it into a ball, place it back on the screen, cover with newspaper, and gently press the pulp out again. If the pulp has become too dry, you will need to resoak it in the dishpan.

8. Flip everything over (like flipping a pancake). Remove the newspaper from the top and gently lift off the screen. The recycled paper will be resting on top of the newspaper used to soak up the excess water.

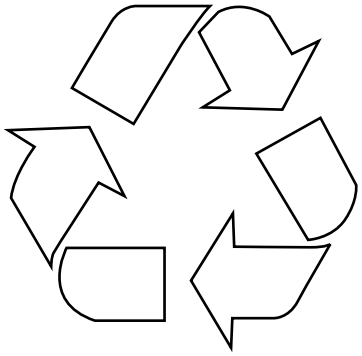
9. Place the recycled paper and newspaper in an area to dry (it will dry quickly in the sun). If drying overnight, place a heavy object, such as a book, on the paper to keep it from curling. The recycled paper should lift off easily from the newspaper when it is dry.



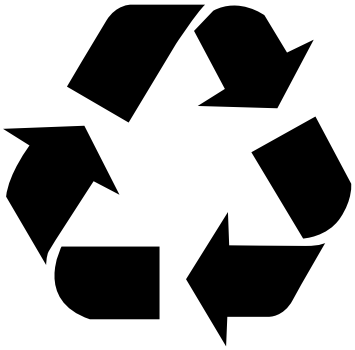
Transparency

CLOSING THE LOOP

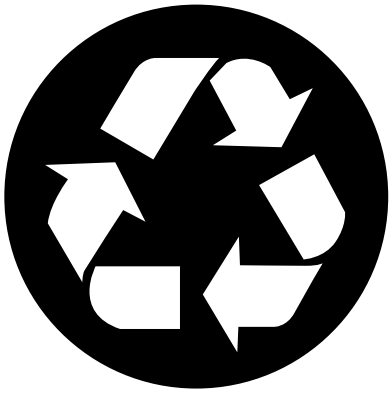
THE MEANING OF RECYCLING SYMBOLS



Carton or paper is made from recycled paper fibers.



The paper is made from recycled paper fibers.



The package is recyclable, although it may not be made from recycled materials.

The three arrows depict the collection, manufacture, and purchase of recycled materials.

BACKGROUND INFORMATION FOR THE TEACHER

Wood that is unsuitable for use as lumber and lumber mill wastes are used to manufacture paper. To save transportation costs, paper mills are usually located near the forests where the wood is harvested. The trees are debarked, chipped, mixed with chemicals, and processed in a large steam-heated pressure cooker called a digester. This helps to break the wood down into cellulose fibers. The fibers are then rinsed with water to remove chemicals, unwanted wood contaminants, and dirt.

The remaining water-wood mixture, called slurry, is fed onto a screen and shaken to intermesh the cellulose fibers. Water is drained through the screen, and the remaining sheet of paper passes through a series of rollers where it is pressed. Heated rollers dry the paper. The dried paper is cut and placed on smaller rolls or cut into large sheets.

In 1995 approximately 31 percent of residential waste consisted of paper.[1] This wastepaper could have been recycled. The paper recycling process is very similar to the process of making paper from trees. The paper is chopped up and mixed with water to make a pulp slurry. Then it is put through a series of washing and/or flotation de-inking processes in which water and/or soap-like chemicals (called surfactants) remove the ink from the paper. Water is drained through the screen, and the remaining sheet of paper passes through a series of rollers where it is pressed and dried. The paper is slit into smaller rolls or large sheets. Later it is cut to desired size.

A single piece of paper may contain new fibers as well as fibers which have already been recycled. Papermaking fibers can typically be recycled five to seven times before they become too short to be recycled again.

Successful recycling requires clean recovered paper which is free of contaminants such as food, plastic, metal, and other garbage. Contaminated paper can introduce impurities and bacteria into the recycling process. Also, different types (or grades) of paper, such as corrugated boxes, newspapers, and office paper, are kept separate because the different grades of paper are used to make particular types of recycled paper products.[2]

Recycling paper conserves natural resources. It saves trees (most of which are grown on tree farms). It saves energy, because it takes 30 to 60 percent less energy to produce the same weight of recycled paper as to make the paper from trees. It reduces air pollution from pulp mills by 74 to 95 percent and lowers water pollution by 35 percent. It also reduces the amount of paper going to the landfill, therefore, extending the life of the landfill.[3]

In this lesson students will be making their own recycled paper. Making recycled paper not only teaches students about the recycling process, but it is also a lot of fun.

Note: For additional information about paper see "The Paper Recycling Process" and "History of Paper" in the "Appendix."

The symbol depicting that a carton is made from recycled paper is white arrows superimposed on a black circle. Three black arrows printed without any circular background also indicates that the paper is made from recycled paper fibers. Three white arrows (with black outline), only with no black circular background, means that a package is recyclable, although it may not be made from recycled materials. The three arrows depict the collection, manufacture, and purchase of recycled materials.[4]

In this lesson students will be making their own recycled paper. Making recycled paper not only teaches students about the recycling process, but it is also a lot of fun.

[1]"Estimated Average 1995 Residential Disposed Waste Stream Composition." California Integrated Waste Management Board.

[2]"Secondary Fiber Recycling." Atlanta, Ga.: TAPPI Press, 1993.

[3]G. Tyler Miller, Jr. *Environmental Science: Working with the Earth* (Fifth edition). Belmont, Calif.: Wadsworth Publishing Company, 1995, p. 346.

[4]E-mail communication from Brian Foran, Associate Waste Management Specialist, California Integrated Waste Management Board, August 26, 1998.

NOTES

LESSON 1: The Basics of Vermicomposting

Note: Before implementing this activity, students will need to know what animals need in order to live. You will need to use an existing lesson (most science programs have lessons on this topic) or design one yourself to teach students the needs of animals, which should include food, water, shelter, air, and a place to live (habitat).

LESSON'S CONCEPT

Food scraps can be recycled through vermicomposting.

PURPOSE

Students are introduced to the basics of vermicomposting and learn about the physical requirements of red worms as they set up a worm bin to demonstrate how food waste and paper can be recycled.

OVERVIEW

In this lesson students will:

- Brainstorm what they know and what they would like to know about worms.
- Set up a vermicomposting bin.
- Classify those items that can be fed to red worms and those that cannot be fed to red worms and write a poem about it.
- Design a chart with pictures of what to feed and what not to feed red worms.
- Record the weight and type of worm food and where it was placed in the worm composting bin.
- Select questions about red worms that they can research in books, on the computer, through videos, and through personal observations.

CORRELATIONS TO CALIFORNIA'S CONTENT STANDARDS AND FRAMEWORKS AND TO *BENCHMARKS FOR SCIENCE LITERACY*

- Students set up a vermicomposting bin in the classroom and keep a class journal of everything that gets put into the bin.
  - "Plants and animals meet their needs in different ways. As a basis for understanding this concept, students know: plants and animals both need water, animals need food, and plants need light." (*Science Content Standards, Grades K–12*; Grade 1; Life Sciences, Standard 2c)
  - "A lot can be learned about plants and animals by observing them closely, but care must be taken to know the needs of living things and how to provide for them in the classroom." (*Benchmarks for Science Literacy,* page 15)
  - "Students collect information about objects and events in their environment." (*Mathematics Content Standards for California Public Schools, Kindergarten Through Grade Twelve,* page 3)
  - "To participate effectively in society, students need to: Develop personal skills . . . group interaction skills (and) . . . social and political participation skills." (*History–Social Science Framework*, page 24)
- Older students do research on worms in various sources.
  - "Students identify the basic facts and ideas in what they have read, heard, or viewed." (*English–Language Arts Content Standards for California Public Schools, Kindergarten Through Grade Twelve,* page 2)
  - Students "understand the purposes of various reference materials." (*English–Language Arts Content Standards for California Public Schools, Kindergarten Through Grade Twelve,* page 13)

SCIENTIFIC THINKING PROCESSES

observing, communicating, comparing, classifying, relating, applying

TIME

60 minutes or more (especially if you need to buy the worm bin and worms) to prepare for the lesson; 60 minutes or more to implement the lesson (depending on whether you have younger or older students and their involvement in preparing the worm bin)

VOCABULARY

compost, organic, organisms, red worm, vermicomposting

PREPARATION

___ **1.** Read the "Background Information for the Teacher" at the end of this lesson.

___ **2.** Obtain a ready-made container measuring approximately one foot deep by two feet wide by three feet long with a lid. Plastic storage containers can be purchased from most large variety stores. If possible, reuse a previously used container or purchase one made from recycled plastic.

- Drill several quarter-inch drainage holes through the bottom of the container.
- Place screen on the bottom of the container. (Red worms will usually not crawl out of the drain holes, because they prefer the dark; however, if your bin becomes too dry or too wet, the worms will leave in search of more favorable conditions.)

___ **3.** Make a transparency of the "Sample Vermicomposting Data Sheet" (page 33).

___ **4.** For younger students (in kindergarten and first grade), duplicate "What to Put and Not to Put in a Worm Bin" for each group of students (page 34).

Note: Some people who vermicompost drill one-inch round holes on each of the four sides of their bins for an additional air supply. These holes are covered with screen, and a glue gun or waterproof tape is used to secure the screens to the container.

MATERIALS

___ Butcher paper on which to write students' responses
___ Vermicomposting container with lid
___ Newspaper (a stack about six inches tall) or classroom paper to be used for bedding (Colored paper and paper with crayon drawings can be used. Do not use glossy advertisements and magazines.)
___ A plastic milk jug for measuring water
___ Water (in a watering can)
___ One or two pounds of red worms, depending on the size of the bin (Red worms can be purchased from bait shops or from worm suppliers. See the list of worm suppliers in the "Appendix." Which can be found on the Board's website.)
___ Four to six cups of garden soil (Do not use sterilized potting soil.)
___ Utility scale (up to 20 pounds) (This scale can be a hanging scale on which students hang a bucket with items to be weighed or a parcel post scale on which students can place a container with items to be weighed.)
___ Large clean plastic bucket or other container (or wheelbarrow) for mixing bedding (Bedding can also be mixed in the vermicomposting bin.)
___ Two boards, or four bricks, or other comparable items to place under the bin so that the bottom will receive sufficient air
___ Sheet of plastic, or large flat garbage bag, or several unfolded newspapers to put under bin in case water leaks through the holes
___ A two-quart plastic container with lid in which to keep food waste to feed to the worms
___ A class worm journal to keep by the worm bin
___ The book *Squirmy Wormy Composters* by Bobbie Kalman and Janine Schaub
___ Nontoxic permanent marker
___ Six, three inch by five inch cards
___ The transparency, "Sample Vermicomposting Data Sheet"
___ For younger students, a copy of "What to Put and Not to Put in a Worm Bin" for each group of students

PRE-ACTIVITY QUESTIONS

A. Ask students:

- After you eat lunch, what do you do with your garbage? *Throw some of it*

away; recycle some of it.

- What do you throw away? *Some paper, food, plastic.*
- What do you do with the paper from your lunches? *Throw it in the garbage can; recycle it; reuse it; compost.*
- What do you do with cans? *Throw them in the garbage can; recycle them.*
- What do you do with food waste? *Throw it in the garbage can.*
- What else can you do with food waste? *Feed it to animals; bury it; compost it.*
- If we could have a container in our classroom with special animals that are easy to take care of and that could eat our food waste, would we want this container? *Yes.*
- Can you guess what animal might eat our garbage in a container in our classroom? (As students name some animals, you might give them hints, like "it is much smaller than a mouse," until a student identifies the animal as a worm.)
- What do we know about worms? (List what students say on a piece of butcher paper.) *They are slimy. I've used them for fish bait. I have some in my garden. I've seen them after it rains. They don't have any hair.*
- What do you want to find out about worms? (List what students say.) (See answers from Betsy Weiss's class.)

Students in Lynda Mooney's first-grade class at Las Palmas Elementary School compile a list of what they know about worms.

What do you already know about worms?
Worms:

- *Live in the ground, under soil, and compost with centipedes and other bugs*
- *Recycle the dirt*
- *Eat garbage*
- *Dig in soil*
- *Take care of gardens*
- *Wiggle to move*
- *Are long and skinny*

What do you want to find out about worms?

- *What happens if they live in the sun? Will they die?*
- *How do they eat?*
- *Do they have teeth?*
- *What do they eat?*
- *Do they sleep underground?*

Submitted by Betsy Weiss's kindergarten and first-grade class, Paden Elementary School, Alameda City Unified School District.

Note: Keep the lists your students developed to use at the end of the lesson.

- Does anyone know what compost is? Lead students to conclude that compost is a soil enricher that helps plants to grow. Tell students that a special type of worm, called a red worm, can eat garbage, like food scraps (e.g., apple cores, banana peels, bread crust). The worms' droppings, called castings, look like rich soil and contain nutrients to help plants grow. These droppings can be collected and placed in the garden or in flower pots.
- How can red worms help to reduce the waste we throw away? *They can eat our food garbage.*
- If "vermi" means worms, what do you think vermicomposting means? *Composting with worms.*

B. Discuss with students the following:

- If we decide to set up a worm composting bin where worms would live, what will we need to know? *How to do it; what worms need to live; who will take care of them.*
- What do animals need in order to live? *Food, water, shelter, air, and a place to live.*

- What do you think red worms need in order to live? *Food, water, shelter, air, a place to live.*

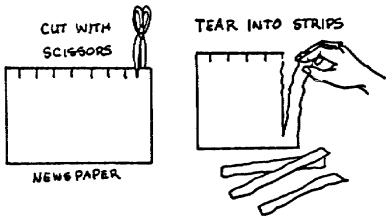
PROCEDURE

Part I, Providing a Habitat for Red Worms

A. Describe the components in a worm bin: bin, lid, paper strips, soil, water, air, red worms, food scraps.

Note: The following could be done in several short sessions by working with one small group at a time, while other groups work on another assignment.

B. Tell students that they will first be making the bedding for the red worms. Provide a stack of paper about six inches tall. Have students cut and tear strips of paper. You will need several grocery bags full or approximately ten to twelve pounds of strips. Newspaper can be easily torn into strips by folding sections and using scissors to snip one inch strips along the fold and then tearing strips starting where the scissors snips began. Adult volunteers can make the snips in the folded paper, and students can tear the strips. Then the strips should be separated from each other so that each strip contains only one layer of paper.



C. Prepare the bedding by completing #1 or #2 below, depending on the grade level of your students (#1 is recommended for students in kindergarten or first grade; and #2, for students in grades two or three).

For younger students

1. The following can be done in the worm bin or in a wheelbarrow or other large waterproof container:

- Place a couple of grocery bags full of paper strips in the mixing container with enough water to dampen the paper, but not so much as to make the paper strips soggy. A watering can works well. To judge how wet the paper should be, think in terms of a squeezed out sponge.
- Add several cups of soil and mix well.
- If mixing is done in a container other than the vermicomposting bin, then place the wet newspaper in the worm bin and distribute the paper evenly.
- Fluff up the paper to provide air.

For older students

2. Mathematics problems could be added to this lesson by having students calculate the proper amount of bedding, soil, and water. Have students:

- Weigh ten to twelve pounds of dry paper strips. They can weigh the paper on a household utility scale.
- Calculate the amount of water needed by multiplying the weight of the paper by three (see the "Note" below). Tell students that a pint of water weighs a pound; therefore, a gallon (eight pints) of water weighs eight pounds.

Students in Ted Schut's first-grade class at Ripona Elementary School prepare bedding for red worms.

Two students from Sharon Janulaw's kindergarten class at Marguerite Hahn Elementary School prepare a worm bin.

Note: Red worms need an environment that has approximately the same moisture content as their bodies, 75 percent. The environment in the bin can be set up by weighing the shredded paper and adding approximately three times as much water (by weight). Once the bin is established, the food waste usually provides enough moisture, and you will probably not need to add water to the bin.

- Place about half of the paper in the mixing container, add about half of the required amount of water to dampen the paper, and mix.
- Add four to six cups of garden soil and the rest of the paper and water.
- Mix well, and if a separate mixing container was used, empty the contents into the worm bin and distribute the paper evenly.
- Fluff up the paper to provide air.

Part II, Composing a Poem About Vermicomposting

A. In this activity, students will write a poem about what should and should not be placed in the vermicomposting bin.

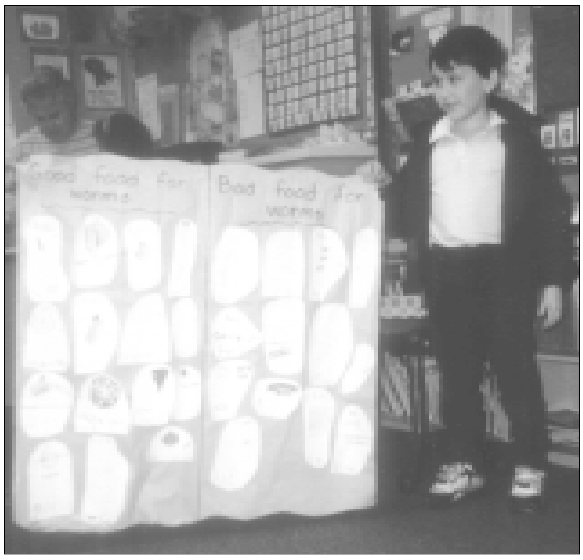
- Tell students that just about any food waste left over from school lunches can be fed to the worms, including bread, fruit, vegetables, and pasta. Note that these food wastes come from plants.
- Materials not to feed worms are meat, bones, and nonfoods, such as plastic wrap or rubber bands.

Note: Although meat and bones can be composted, these materials take a long time to decompose, and their presence in a worm bin may attract rodents (mice and rats) and flies.

B. Ask students to make a chart with pictures and words of what to feed and what not to feed red worms. One way to do this is described below:

- Brainstorm and list items that are common in students' lunches.
- Write the name of each item on a separate scrap of paper, place these scraps in a container, and let students take one.
- Ask students to draw and write the name of the item under each drawing.
- Write the following headings on chart paper: okay to feed to worms / not okay to feed to worms.
- Ask students to glue their drawings under the appropriate category. The placement of the drawings should be agreed upon by a majority of the students.
- Hang the chart paper by the worm bin.

Note: A chart, "What to Put and Not to Put in a Worm Bin," on page 34 is included in this lesson to use with younger students.



Students in Lynda Mooney's first-grade class at Las Palmas Elementary School develop a chart illustrating "Good Food for Worms" and "Bad Food for Worms."

C. Ask students to meet in groups and write a poem about what should and should not be placed in a worm bin.

Note: For younger students, consider writing a poem as a class.

D. If poems were written by groups, have students read the poems to the class.

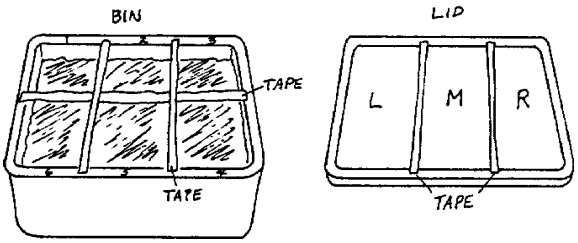
Part III, Adding Worms and Food

Note: Do this before lunch.

A. Show students how to weigh something (e.g., a book). Have students weigh the worms before they place them in the bin, and record the worms' weight on the transparency "Sample Vermicomposting Data Sheet." (There are approximately 1,000 worms in a pound.) Ask a couple of students to gently place the worms on top of the bedding, spreading them out evenly. Keep the bin uncovered; within a few minutes, the worms will move down into the bedding to avoid light.

B. Have students write numbers 1 to 6 on three-inch by five-inch cards. Tape these to the top of the lid. You can also use tape to separate the sections on top of the bin and write the numbers with a marker on the top edges of the bin (see illustration). Students should use this diagram for placing food waste in different sections of the bin. This will enable students to keep track of where and when the food waste was placed. These sections can also be drawn on the back of the class worm journal for reference.

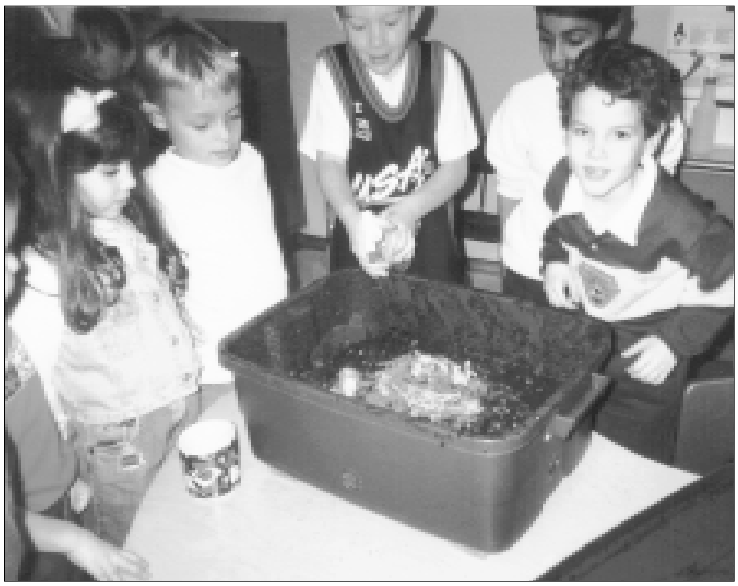
Note: For younger students, separate the worm bin into three parts: a left side (L), a middle section (M), and a right side (R). Students can alternate feeding sides.



C. Before lunch or snack time, separate the class into four teams. Ask each team to bring back to class one piece of food waste approximately the size of an apple core. These food items will be fed to the worms. Examples of food waste that students can bring are: apple core, banana peel, pieces of bread crust. Also see "What to Put or Not to Put in a Worm Bin" or the chart that students developed in "Part II," section "B."

D. Collect the lunch or snack food waste from students and place it in a plastic container with a lid.

- Have students weigh lunch leftovers and record the weight.
- Ask one student to add approximately one-half pound of the food waste to the vermicomposting bin. The first pile of



Students in Ted Schut's first-grade class at Ripona Elementary School add food scraps to the worm bin.

A student in Mario Chang's second-grade class at Mission Education Center places food into the first corner of the vermicomposting bin.

food should be placed in the corner for week one (based on the food waste pattern diagram) or on the left side (for younger students).

Note: Students should realize that it is important not to overfeed the worms; otherwise, the bin will have too much food for the worms to process, which will cause the bin to become too moist and acidic for the worms. Students should feed the worms a half-pound of food waste only once a week for the first three weeks until the red worms become established. Also, the worms will eat the paper, so keeping the food waste to a minimum will not hurt the worms. Once the worms are acclimated, they will be able to consume half their weight a day. Food scraps can be kept in a sealed container until it is time to feed the worms.

Note: With the small bin, you will not be able to compost a lot of food. If your class is interested in participating in large scale vermicomposting, see the "Resources" section in this lesson.

E. Project the transparency "Sample Vermicomposting Data Sheet" and have students help you fill in the information.

F. Do #1 or #2 below . (It is recommended that #1 be used with younger students and #2 with older students.)

For younger students

1. Use the transparency to record information when additional food is added to the bin. The information can be transferred from the transparency to a copy of the sheet and kept by the worm bin.

For older students

2. Keep a class worm journal next to the bin. Students can copy the data in their own journals.

- In the class's worm journal, students could record how much food by weight the worms are getting, what type of food was fed, and into what area of the bin the food was placed. The weight of paper added to the bin could also be recorded.
- Practice writing in the class's worm journal as a class and in groups until all students know how to do it.
- Charts can be developed to be included in the class's worm journal, or the "Monthly Vermicomposting Data Sheet" can be used on which to record data.

Note: Directions for harvesting compost from the worm bin are described in Lesson 5 in this unit.

DISCUSSION/QUESTIONS

A. Why is vermicomposting a good idea? *Through vermicomposting, paper and food waste are recycled; therefore, less garbage ends up in our landfills. The compost helps to improve the soil.*

For younger students

B. What are the main ingredients of a vermicomposting system? *A vermicomposting system's components include the following:*

1. *A place where the worms live—the box*
2. *Living things—red worms and bacteria and fungi*
3. *Food*
4. *Moisture*
5. *Air*
6. *Preparing, maintaining, and harvesting the bin: preparing the bedding, adding worms, burying garbage, separating worms and castings, using castings*

APPLICATION

A. Have students look at the questions they listed in "Pre-Activity Questions" about what they wanted to find out about worms. Are there any questions that they now can answer and place on the list, "What do we know about worms?" List students' responses.

B. Do #1 below with younger students and #2 with older students.

For younger students

1. Have groups of students make a collage of "worm food" cut out of magazines and newspapers.

For older students

2. Ask students to add to the list of questions they began in the "Pre-Activity Questions" about red worms and about vermicomposting. Have each student or group of students select a question that they would be willing to research in books, on the computer, through videos, and through personal observations. (A question can also be selected to be

researched by the whole class, and answers can be compiled and compared.)

- Show them the book *Squirmy Wormy Composters* by Bobbie Kalman and Janine Schaub. Encourage students to look through the book and to come up with additional questions about red worms and vermicomposting.
- Keep the list of questions posted in the classroom, and encourage students to post and report facts to the class when they learn new information. Consider having students print the fact they learned on a strip of paper (e.g., four inches wide by six inches long), and have them tape it under the question they think it relates to.
- Examples of questions that students can research are listed below:
  - How much food did our worms eat in one week or one month? (Students weigh the food as it is added and observe its decomposition.)
  - What foods decomposed faster than others? (Students keep track of the amount of a specific food and compare it to another type of food.)
  - How often should water be added? (Students keep track of how much water they added when they first set up the bin. They record how much water they needed to add through a specific period of time.) Note that with some bins no additional water will be needed, whereas with other bins (especially in dry climates), adding water will be necessary.
  - Where do worms tend to congregate? Do they seem to prefer certain foods to others? (Students survey the bin.)
  - Do smaller pieces of food waste tend to break down faster than larger ones? (Students set up experiments to find out the answer.)
- Ask students whether there are any ideas stated in the "What Do We Know About Worms" (listed on butcher paper at the beginning of this lesson) which need to be changed or deleted because of what they have discovered.

Homework Assignment: Ask students to do a waste audit at home and measure how much food waste the family produces in one day:

Option 1: Students list the type of food that is being thrown away.

Option 2: Students gather food waste in a plastic bag and weigh it on a bathroom scale.

Note: For younger students, ask students to share with their parents what they have learned about vermicomposting. Then they can talk about what their family does with food wastes. Parents could record this or sign a form that indicates that the student did the assignment.

C. On the chalkboard write the types of food and the weights that students discovered concerning home food waste. Conduct a

(Use school's letterhead.)

Dear Parent or Guardian,

Please read the following information with your child:

We are studying how red worms can be used to turn food waste into compost. We are calculating how much food waste the students in our class could compost using worms. Would you please help your child do one of the following:

• Option 1: Help your child record the type of food scraps being thrown away and have your child bring this list to school.

• Option 2: Place the food scraps in a plastic bag and use a bathroom scale to weigh them. Please write the weight of the food on a piece of paper and have your child bring the information to school.

Thank you,

discussion on how much trash can be kept from going to a landfill if everyone had a vermicomposting bin at home. A graph could be designed for the data collected.

EXTENSIONS

A. Obtain a copy of the poem "Sarah Cynthia Sylvia Stout" by Shel Silverstein. (See "Resources" in this lesson.)

- Have students identify which garbage items described in the poem are acceptable to put in worm composting bins and which items are not.
- Discuss with students what Sarah should have done with her garbage at the very beginning. *She should have had a vermicomposting bin for garbage that can be fed to red worms and throw the rest of the garbage into a garbage can to be taken to a landfill.*

B. Have students compare a red worm to a night crawler**.**

C. Have students participate in a science fair by conducting humane projects on red worms.

RESOURCES

Video

Wormania! Available from The Let's Get Growing! Company, 1900 Commercial Way, Santa Cruz, CA 95065; 1-800-408-1868; FAX 408-476-1427 (26 minutes).

Stars Mary Appelhof and songs by Billie B. Explains the natural history of the red worm. Shows a baby worm hatching; explains how worms move and describes how they reproduce. Although designed for students in upper-elementary grades, some parts would be very interesting to younger students.

Audiotapes

Dirt Made My Lunch. Recorded by the Banana Slug Band; includes the song "Decomposition" by Steve Van Zandt. Music for Little People, 1989.

A tape and booklet with the words to this and other songs.

Nature Nuts. Recorded by Mary Miche, 2600 Hillegass Ave., Berkeley, CA 94704; 510-845-8417.

Includes a song "Recycle Blues" that includes lyrics on composting.

Books

Appelhof, Mary. Illustrated by Mary Frances Fenton. *Worms Eat My Garbage*. Kalamazoo, Mich.: Flower Press, 1997.

Describes how to set up and maintain a composting system in which worms recycle food waste and produce fertilizer that can be used for house plants and garden areas.

Kalman, Bobbie, and Janine Schaub. *Squirmy Wormy Composters.* New York: Crabtree Publishing Company, 1992.

Describes red worms and how to set up a vermicomposting bin. Contains ideas for activities for students to learn more about red worms.

Ross, Michael Elsohn. *Wormology*. Photographs by Brian Grogan and illustrations by Darren Erickson. Minneapolis: Carolrhoda Books, Inc., 1996.

Contains information, colored photographs, and diagrams of earthworms. Describes activities that can be done with worms.

Silverstein, Shel. *Where the Sidewalk Ends.* New York: Harper and Row, 1974.

Contains a selection of poems, including "Sarah Cynthia Sylvia Stout."

Activity Guides

Appelhof, Mary, and others. *Worms Eat Our Garbage*: *Classroom Activities for a Better Environment*. Illustrated by Mary Frances Fenton and Nancy Kostecke. Kalamazoo, Mich.: Flower Press, 1993.

Contains activities for students to learn about red worms.

Composting Across the Curriculum. A Teacher's Guide to Composting. San Rafael, Calif.: Marin County Office of Waste Management, 1993.

Contains activities about composting and vermicomposting.

Do the Rot Thing. A Teacher's Guide to Compost Activities. San Leandro, Calif.: Alameda County Waste Management Authority and Source Reduction and Recycling Board, 1997.

Contains activities about composting and vermicomposting.

Eulo, Anthony. *Worms, Worms, and More Worms: A Guide to Vermicomposting*. Sacramento: California Integrated Waste Management Board, 1996.

Contains background information on how to set up a vermicomposting system and pro-

vides ideas for many activities that students could do concerning worms.

Grossman, Shelley C. and Melissa Weitzel. *Recycle with Earthworms: The Red Wiggler Connection*. Illustrated by Lisa Marie Donnabella. Eagle River, Wis.: Shields Publications, 1997.

Describes various types of worms, the anatomy of worms, and methods for composting with red worms.

Newsletter

Worm Digest. Edible City Resource Center, Box 544, Eugene, OR 97440.

A newsletter containing information about teachers using worms in the classroom, activities to learn about worms, workshops, and resources. Back issues are available.

Websites

http://www.globalclassroom.org/worms.html

Information regarding a first-grade class that is vermicomposting. Included in this site are comments from the students regarding the activities.

http://www.interware.net/~levine/worms/

Primarily for classroom work with worm bins. Provides classroom instruction and materials.

http://www.wormdigest.org/

Worm Digest is a quarterly newsletter that reports about worms and worm composting (vermicomposting) on all levels worldwide. Its aim is to network people, information, and resources concerning the use of worms for organic waste conversion and soil enrichment.

http://www.wormwoman.com/frameindex.html

The "Worm Woman's" web page provides an introduction to the methods of vermicomposting, covering materials and the process.

http://www.ciwmb.ca.gov

The website for the California Integrated Waste Management Board and includes the most current list of worm suppliers.

Additional websites are listed in "Appendix F–VI."

Other Resources

Environmental Education Compendium for Integrated Waste Management and Used Oil. Sacramento: California Department of Education and California Integrated Waste Management Board, June, 1999. Copies are available through the California Integrated Waste Management Board.

Contains information about and evaluations of many curricula on waste management (including composting) and used oil.

A small plastic vermicomposting bin suitable to use indoors sits on top of the large wooden outdoor vermicomposting bin at Laytonville Elementary School.

Transparency

SAMPLE VERMICOMPOSTING DATA SHEET

Date bin was set up:

Number of worms (in pounds or actual number of worms):

Kind of bedding used and weight (or amount):

Harvest date(s):

Draw a picture of the worm bin and assign numbered plots to its surface so that you can track the decomposition of food placed in each numbered area.

Month _____

Date	Weight of food	Type of food	Buried in site #	Notes

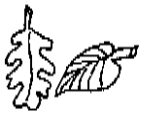
WHAT TO PUT AND NOT PUT IN A WORM BIN

Put the following in a worm bin:

- Shredded paper products
- Fruit and vegetable trimmings

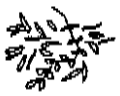

- Grains, beans, or breads (without butter, margarine, or mayonnaise)

- Egg shells
- Fallen leaves


- Tea bags
- Coffee grounds and filters

- Lawn clippings and young weeds

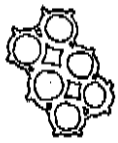


Do not place the following in a worm bin:

- Meat products
- Dairy products



- Rocks
- Plastics



- Glass
- Metal products (e.g., aluminum cans)

BACKGROUND INFORMATION FOR THE TEACHER

Vermicomposting is the process of using red worms and microorganisms (like bacteria and fungi) to change organic waste (e.g., food scraps and paper) into useful rich compost, full of nutrients that plants can use for growth. Vermicomposting can help to reduce household and school food waste that goes to a landfill. In 1995 food waste made up about 9 percent and paper made up about 31 percent, by weight, of the household garbage sent to landfills in California.[1]

In order to vermicompost in the classroom, students will need to prepare a bin to hold the red worms and provide bedding and appropriate organic materials to feed the worms. In addition students will need to monitor and control the environment in the worm bin so that it is conducive to worms and composting. This effective composting system can also be set up outdoors. For information on how to set up large-scale outdoor vermicomposting, see "Resources" at the end of the lesson.

Red worms *(eisenia foetida)*, also called manure worms or red wigglers, are the type of worm used in worm composting systems. Red worms naturally live in decaying leaf litter, compost piles, or manure just above the ground's surface. Animals and plants that die and begin decomposing provide food for the worms. In a worm bin, red worms readily consume food scraps and paper, and each red worm can eat half of its body weight every day.

Red worms are ideal for use in vermicomposting, because they can live within whatever space is available, tolerate a wide range of temperatures (especially the warm temperatures found within the average classroom and home), reproduce quickly, and mate throughout the year. (For information about reproduction of worms, see the "Background Information for the Teacher" in "Lesson 3, Cycles in Nature and Red Worm Development.") The population of red worms is limited in the worm bin by the amount of food available and by the amount of free bedding that has not been converted into castings (worm excrement).

[1]"Estimated Average 1995 Residential Disposed Waste Stream Composition." California Integrated Waste Management Board.

Red worms can be purchased from worm suppliers. For the most current listing of worm suppliers, visit the California Integrated Waste Management Board's website at http://www.ciwmb.ca.gov or see "Appendix D."

Worms found in an outdoor compost pile would probably be suitable for indoor vermicomposting, but there are definitely some worms found in the ground which are not suitable. For example, night crawlers, or *lumbricus terrestris*, are not recommended for the worm bin, because they need large amounts of soil and cannot survive in soil with temperatures above 50° F.

Other organisms (living things) in the vermicomposting bin include bacteria, which break down most organic matter, and fungi, which break down the tougher materials, such as cellulose (found in materials like paper), that bacteria cannot break down.

Red worms have no eyes, but they do have sensory cells on their skin which detect light. They prefer darkness; therefore, keeping worms in a dark container (with a lid) is important.

The bin for red worms should be shallow (8 to 12 inches deep) because red worms tend to be surface feeders. Therefore, a shallow plastic storage container, with drainage holes works best as a worm bin.

The least expensive and easiest bedding to get for red worms is shredded newspaper. The white paper found in schools and offices can also be used for bedding. Avoid glossy advertisements and magazines.

Worms breathe by absorbing oxygen through the wet surfaces of their bodies. Their bodies must be moist in order for the exchange of air to take place. Therefore, the newspaper (or other paper) must be moistened to keep the red worms' habitat in the bin damp. The bedding should be at least six inches deep after moistening. Since paper can be fluffed up, oxygen is provided for the worms. Oxygen is necessary not only for the worms but also for the microorganisms that are breaking down the food waste.

Make certain that the contents of the bin do not get soggy. If their environment is too wet, the red worms become uncomfortable because of the rise in acidity levels. Holes on the bottom of

the bin will allow excess water to drain out. This water, called "compost tea," can be collected and used as a natural concentrated fertilizer for plants.

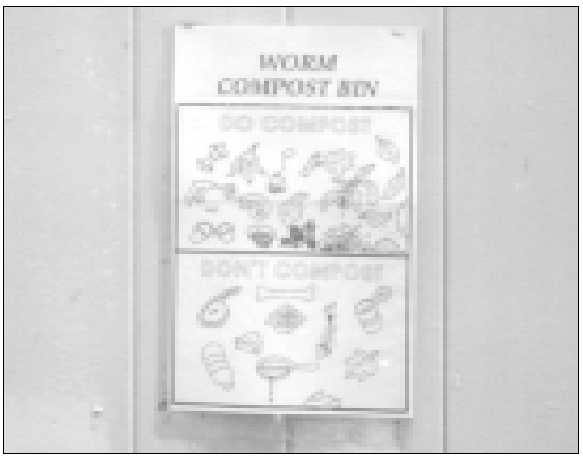
Worms have gizzards and need a small amount of gritty material to help grind up the food waste. Therefore, several cups of soil should be added to the bin. Before adding the soil, check to make sure that the area that the soil came from was not recently treated with pesticides. An even better source of grit is rock dust, which is ground up rocks. Many nurseries and garden stores sell bags of rock dust. It is rich in minerals and will help balance the acidity of the bin.

Two thousand worms weighing approximately 2.2 pounds (one kilogram) can be fed about 1.1 pounds of food waste each day. Any plant food waste can be put into the bin. Avoid placing animal products in the bin. Meat and cheese attract mice, rats, and other pests and may create an unpleasant odor as they decompose.

It is possible to overload the system by adding too much food waste. Plan to have students keep track of the weight and placement of food buried and check how rapidly the worms are processing the food scraps and paper.

Note: For additional information about maintaining the bin, see "Maintaining a Vermicomposting System" in "Appendix D–II."

Safety Note: If vermicomposting is used at a student's home and cats are present, make certain that students and parents know that cats should not be allowed to use the vermicomposting bin as a litter box. Cat feces can contain a disease-causing organism called *toxoplasma gondii,* which is harmful to humans, especially pregnant women. Damage to the brain of the fetus can result from contact with this organism.



This sign is posted above each outdoor vermicomposting bin at Cesar Chavez Elementary School, San Francisco Unified School District.

4–6 Module

Introduction to the 4–6 Module of *Closing the Loop: Exploring Integrated Waste Management and Resource Conservation*

The lessons in *Closing the Loop*: *Exploring Integrated Waste Management and Resource Conservation* encourage students to be positive role models by examining their waste management habits and by voluntarily participating in projects that improve their school and community. The lessons in *Closing the Loop* (CTL) create a laboratory for learning. Students learn concepts and explore issues concerning natural resources and integrated waste management and apply the concepts in the classroom and in the world outside their school.

This unit was rated "number one" by a committee of teachers who evaluated nearly 100 curricular and activity guides for the 1999 edition of *Environmental Education Compendium for Integrated Waste Management and Used Oil.*

The 4-6 Module of the 2000 edition of Closing the Loop is composed of four units and an overview of each unit. A tab on teh right-hand side of each right-facing page identifies the module and unit number. Units 1,3, and 4 contains five lessons, and Unit 2 is made up of 12 lessons. The titles of the units are:

- Unit 1: Managing and Conserving Natural Resources
- Unit 2: Reducing, Resuing, and Recycling
- Unit 3: Composting
- Unit 4: Proper Management of Household Hazardous Waste

The overview of each unit contains the following components:

- The unit's concept(s)
- Each lesson's title, concept(s), and overview
- A book or a list of books required to imple ment each unit (and sometimes additional books recommended for the unit)
- Projects that students can do and examples of classes participating in specific projects

By using CTL, teachers will be following recommendations from California's newly adopted content standards and from curricular frameworks i a conceptual, interdisciplinary, and hands-on manner. If a teacher wishes to replace an activity described in CTL with another activity from another curricular guide, that can be done easily. However, it is important that the main concept of each lesson be preserved, or the lesson will no longer fulfill the intent of it's original design.

The California State Board of Education's content standards from the following documents were used in the *CTL* lessons:

- *Science Content Standards, Grades K-12*, Prepublication Version, August 26, 1999
- *English-Language Arts Content Standards for California Public Schools, Kindergarten Through Grade Twelve*. Sacramento: California Department of Education, 1998
- *Mathematics Content Standards for California Public Schools, Kindergarten Through Grade Twelve*. Sacramento: California Department of Education, 1999

Note that only a prepublication version of the Science Content Standards was available at teh time that this curriculum was written. However, all cited science content standards have been adopted by the California State Board of Education.

The following state frameworks are also cited i the CTL lessons:

- *Science Framework for California Public Schools, Kindergarten Through Grade Twelve*, 1990
- *History-Social Science Framework for California Public Schools, Kindergarten Throug Grade Twelve*, 1988
- *The Visual and Performing Arts Framework for California Public Schools, Kindergarten Through Grade Twelve*, 1996

It is recommended that Unit 1 on natural resources be taught first, so students can get background information on natural resources and why they are important and so that students can understand the connection between integrated waste management and the conservation of natural resources. This unit sets the stage for understandein why reducing, reusing, and recycling are so important.

Ideally, the four units in the 4-6 Module of CTL should be taught in the order presented. Within the units, the lessons should also be taught in the order presented. However, it is understood that some teachers prefer to select lessons to incorporate in their curriculum; therefore, an attempt was made to make each lesson stand its own (although sometimes connections to other lessons are suggested).

Each lesson provides step-by-step instructions on how to implement the activities in the lesson. More experienced teachers may choose not to follow this lengthier explanation of the activities. Instead, they can use the overview of each unit as an outline of what they will have their students do in each lesson. They might wish to develop their own activities with the lesson's concepts in mind. As needed, they can review the instructions specified in the lessons and use parts of these instructions when developing their own instructional strategies.

Throughout teh CTL curriculum, the author has recommended that reused materials be used in the lessons. It is also important for teachers to model reducing, reusing, and recycling classroom materials, including buying products made from recycled materials. As one of the teachers who field-tested the CTL curriculum said:

> *I feel that we, as teachers, are role models for students. They see me reusing materials and recycling every day and "copy" what I model. I want my students to see the difference one class can make at our school. Too many times people think that one person, or one paper or can, cannot make an impact. I show that it does. Students model at home what I teach in class. Parents see the students and (hopefully) model them.*
>
> –Barbara Love, fourth-grade teacher and field tester for *Closing the Loop,* Fletcher Hills Elementary School, La Mesa-Spring Valley School District

In most lessons, when teachers develop a list with their students, they have the option of writing the list on a chalkboard or on butcher paper. However, if a list needs to be kept and used again in future lessons, the butcher paper provides a more permanent alternative and eliminates the possibility that the contents will be erased. It is recommended that both sides of the butcher paper be used for writing, and then the paper can be used in art projects, composted (or vermicomposted), or recycled.

In this curriculum students have opportunities to engage in many different types of projects. For example, some students conduct research by gathering information from books and the internet on different natural resources, or they may gather information from a speaker about their local landfill. Some projects are relatively simple, such as reusing or recycling paper in the classroom or designing a game made out of discarded materials. Others are much more involved, such as planting shrubs and trees on the school grounds or participating in a coastal cleanup of litter. And still others will take large abounts of time and dedication, such as designing a campaign to reduce waste on a school-wide basis; organizing a school-wide recycling program; composting cafeteria food waste; or designing a newsletter to let community members know about the importance of composting and guidelines for reducing, reusing, and recycling various materials.

Examples of projects and classes participating in some of the projects are listed in the "Overview" for each unit. For more information on project-based learning, see "Tips for Implementing Projects." Also, the Autodesk Foundation provides information for educators interested in project-based learning. The Foundation's website is http://www.autodesk.com/foundation.

Fifth-grade teachers are encouraged to participate in the Jiminy Cricket's Environmentality Challenge, a contest sponsored each year by the Walt Disney Company, Inc., and the State of California's Environmental Education Interagency Network. The winning class gets to go to Disneyland, where the students are honored. For more information visit the website at http://www.oehha.ca.gov/ceein/jim/index.htm or call the hotline at 1-800-290-0299.

Make public what your class is doing when implementing *Closing the Loop* and publicize some of its recommended projects. Have students design presentation panels, submit photographs and news articles to local newspapers, tape conversations with students about their projects, videotape brainstorming sessions, and show students' work during the school's open house.

LESSON 2: Away to the Landfill

LESSON'S CONCEPTS

- Solid wastes are made from a variety of natural resources. Once these wastes are placed in a landfill, they are no longer available to be reused or recycled, and the natural resources used to make them are wasted.
- Landfills are the most common sites used for waste disposal.
- Landfills take up space and are located in areas that are, or once were, habitats for people, wildlife, and other living things.
- Modern landfills are designed to protect the environment.

PURPOSE

Students learn how landfills are constructed to protect the environment. They will conclude that once objects are placed in a landfill, these objects can no longer be used; and, therefore, the natural resources used to make the objects are wasted.

OVERVIEW

In this lesson students will:

- Construct in a bottle a model of a landfill.
- List what goes into a landfill and determine what happens to the natural resources used in objects that end up in a landfill.
- Demonstrate that waste takes up space in a landfill and that some waste can be diverted from a landfill by being reused or recycled.
- Classify items in their models of landfills according to what can be reduced, reused, or recycled.
- Observe over time the changes occurring in the waste in their models of landfills.
- Analyze school waste that has been placed in a landfill.
- Discuss alternatives to putting school waste in a landfill.

CORRELATIONS TO CALIFORNIA'S CONTENT STANDARDS AND FRAMEWORKS AND TO *BENCHMARKS FOR SCIENCE LITERACY*

- Students construct a landfill model in a bottle to learn how landfills are constructed to protect the environment.
  - "(People) need to exercise judgment, care, and planning in their use of natural resources . . . and in their practices of disposing of wastewater and materials." (*Science Framework*, page 125)
  - "Public landfills must be planned responsibly . . .." (*Science Framework*, page 97)
  - "To develop geographic literacy, students must: . . . Understand human and environmental interaction." (*History–Social Science Framework*, page 16)
- Students categorize classroom waste items into those that can be reduced, reused, or recycled.
  - "Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept . . . Students will classify objects . . . based on appropriate criteria . . .." (*Science Content Standards, Grades K–12*; Grade 5; Investigation and Experimentation, Standard 6a)
  - "Discarded products contribute to the problem of waste disposal. Sometimes it is possible to use the materials in them to make new products, but materials differ widely in the ease with which they can be recycled." (*Benchmarks for Science Literacy*, page 189)
- Students describe what they see when they go on an imaginary tour of a landfill. They discuss the pros and cons of landfills.

- "Students listen critically and respond appropriately to oral communication. They speak in a manner that guides the listener to understand important ideas by using proper phrasing, pitch, and modulation." *(English–Language Arts Content Standards for California Public Schools, Kindergarten Through Grade Twelve*, page 26)

SCIENTIFIC THINKING PROCESSES

observing, communicating, ordering, classifying

TIME

45–60 minutes to prepare; 60 minutes to implement the lesson; plus time to examine the contents of the landfill in a bottle one month later

VOCABULARY

landfill

PREPARATION

___ **1.** Read the "Background Information for the Teacher" at the end of this lesson.

___ **2.** Contact the waste manager or local recycling coordinator (check the telephone directory, or call the California Integrated Waste Management Board's Public Education and Assistance Section at 916-255-2385 to get the phone number for your city's or county's solid waste department, which is often part of the Department of Public Works in your community). Ask for information about the nearest landfill. If possible, have the coordinator send you photographs of, and other information concerning, the landfill. Also, ask whether the coordinator is willing to come to speak about solid waste to the class or to set up a field trip.

___ **3.** If possible, arrange to take students to visit a local landfill or take slides or make a video of the landfill to show to the class.

___ **4.** Obtain the video, *Kids Talking Trash*, available from the California Integrated Waste Management Board.

___ **5.** Ask students to bring in a two-liter beverage container and a plastic grocery bag.

___ **6.** If needed, precut the two-liter bottles to prepare them for students to use. See "Procedure," section "B."

___ **7.** Make transparencies of "Construction of a Landfill in a Bottle" (page U1–25); "Layers in a Landfill in a Bottle" (page U1–26); "Diagram of a Landfill" (page U1–27); and "Waste Stream from Schools" (page U1–28)

MATERIALS

___ A trash can of clean classroom waste
___ Plastic tarp or cloth sheet on which to spread out the waste
___ Piece of butcher paper on which to make a chart
___ A photograph, book, or video (e.g., *Kids Talkin' Trash)* that shows a landfill
___ Two rinsed two-liter beverage containers and caps for each pair of students
___ One plastic grocery bag for each pair of students
___ A one-gallon bucket of garden soil (Do not use sterilized potting soil.)
___ A one-gallon bucket of gravel
___ Scissors, tape, two rubber bands, and utility knives
___ Assorted small pieces of clean nonhazardous waste between one-half and one-inch long (e.g., pieces of apple cores, banana peels, bread pieces, leaves, aluminum foil, bottle caps, rubber bands, pennies, pieces of cloth, plastic toy, newspaper, copy paper, and plastic scraps) (Use some materials from the classroom's trash can.)
___ Clay soil (if necessary, garden soil mixed with clay to give the soil a clay-like texture); approximately one half-cup per two-liter beverage container
___ A pair of plastic or garden gloves for each pair of students
___ Transparencies of "Construction of a Landfill in a Bottle," "Layers in a Landfill in a Bottle," "Diagram of a Landfill," and "Waste Stream from Schools"

PRE-ACTIVITY QUESTIONS

A. Spread the garbage from the classroom trash can on a plastic tarp or cloth sheet for students to see. Ask students:

- What should we do with this waste or trash? *Throw it in a garbage can. Throw it away.*
- What happens to our trash when we throw it in a garbage can? *The garbage company picks it up.*
- After the garbage company picks it up, where is it taken? *To dump; to a landfill.*

B. Make a chart labeled "What Goes in a Garbage Can?" on a piece of butcher paper. Ask students what goes in a garbage can, and list their responses on the chart. Keep this chart to use at the end of this lesson.

What Goes in a Garbage Can?

- *Paper*
- *Food scraps*
- *Tin cans*
- *Candy wrappers*
- *Gum wrapper*
- *Plastic food containers*
- *Milk jugs*
- *Grass clippings*
- *Leaves*
- *Old clothes*
- *Aluminum cans*
- *Diapers*
- *Styrofoam*
- *Broken toys*

Submitted by Janet Cohen's sixth-grade class, Gold Trail Elementary School, Gold Trail Union School District.

C. Have students complete the following sentence in their journals: "I put my garbage in a garbage can; then it goes . . ." Prompt students with the following questions:

1. What happens to the garbage after it is placed in a garbage can?
2. Who moves it?
3. How does it get in the garbage truck?
4. Where does the garbage truck take it?
5. What happens to the garbage then?

D. Ask students to share their journal entries.

- Discuss where most garbage ends up. *In a landfill.*
- Ask whether anyone has seen a landfill and encourage students to describe one.
- Show photographs, read sections of a book, or show a video about landfills.

E. If possible, have the local waste manager or recycling coordinator come and speak to your class.

Note: Keep the waste from the classroom and use some of it in the models of landfills.

Students from Valley Oak Elementary School look at garbage from a garbage can.

PROCEDURE

A. Tell students that they will be building landfill models in bottles to learn more about the construction requirements for landfills. Provide two two-liter bottles for each pair of students.

B. The following are directions for preparing the bottle for the landfill model in a bottle. To help you prepare the bottles, see "Construction of a Landfill in a Bottle" in this lesson. Cut two two-liter bottles, as shown in the diagram:

- Cut Bottle B nine inches from the cap. For safety, make an incision with the utility knife and then let the students cut around the bottles with scissors (for younger children, the two-liter bottles will need to be precut). If the edges are jagged, trim them with scissors and place masking tape over them.
- The base of Bottle A will be the base of the landfill.

Submitted by Ed Malaret, fifth-grade teacher, Marguerite Hahn Elementary School, Cotati–Rohnert Park Unified School District.

- Leave the screw top on Bottle B.
- Turn the top portion of Bottle B upside down and place it on top of the base.
- After filling the landfill, you will place the top of Bottle A on top of the inverted Bottle B to form the cap.
- Recycle the bottom portion of Bottle B.
- Place a cup of gravel in the bottle to represent an aquifer. An *aquifer* consists of rock, sand, or gravel which stores groundwater.
- Place one-half cup of soil (about two inches) on top of the gravel in the bottle to represent the ground.

C. Show the transparency "Layers in a Landfill in a Bottle." Tell students that all new landfills require clay soil, a heavy (60 mil HDPE) plastic liner, gravel, and soil to be placed on the ground before waste is added. Note that in most new landfills and those that are being expanded, a geotextile cushion is placed above the plastic liner and below the crushed rock or gravel to keep the rocks from piercing the liner. A geotextile cushion is a soft, waterproof, approximately 1/4-inch thick material that looks like outdoor carpet. Some of these cushions have a layer of rigid plastic netting sandwiched between soft material. Sometimes a geotextile cushion is placed on top of the crushed rock or gravel to keep the soil from mixing with the rock. In some landfills, a geotextile cushion is also placed below the plastic liner. In this lesson the geotextile cushions were omitted in the landfill in a bottle to make it easier for the students to build the model.

- Have students place the following materials in the order listed:
  - A layer of clay soil about one-inch high on top of the existing soil
  - A plastic liner over the clay soil
  - A layer of gravel over the liner
  - A layer of soil over the gravel
- Ask students why they were asked to place clay soil, a plastic liner, gravel, and soil in the bottle before they added the waste. *To keep the waste from contaminating the soil.*
- If needed, explain to students that when it rains, the water can go right through the landfill and mix with the waste. Then this polluted water can percolate through the soil and pollute the groundwater. So before the waste is dumped in a new landfill, a layer of clay soil, a liner of plastic, gravel, and more soil must be added. The clay soil and liner help to keep the water that seeped through the waste from reaching the groundwater. Some cities and counties are also expanding their landfills. All of these expansions require a layer of clay soil, a plastic liner, gravel, and additional soil to be placed before any waste is added.

D. Provide clean pieces of waste to students. Ask students to:

- Record in their journals the type of waste they plan to place in their landfill models.
- Place the pieces of waste on top of the soil, piling the waste about two inches high.
- Cover the garbage with a half-inch layer of soil (see "Layers in the Landfill in a Bottle").

- Add a second layer of garbage and top it with a one-inch layer of soil.

E. Ask students why the garbage is covered with soil at the end of the day. *To keep garbage from being moved by the wind; to keep it from creating an odor; to keep animals away from it.*

F. Ask students to predict how the garbage would change in four or more weeks.

G. With the class, compile a list of items that were placed in the landfill. Have students identify natural resources from which each item was produced.

H. Show the first part of the video *Kids Talking Trash*. Discuss what the video says about landfills.

Homework Assignment: Ask students to use descriptive words to name the landfill that they designed. They should also describe why they selected that name. (They should write more than "I liked the name.")

I. Ask students to share with the class the names they selected for their landfills.

DISCUSSIONS/QUESTIONS

A. Discuss with students:

- What is waste? *Anything that people don't want.*
- Where do all the products we buy come from? *Natural resources.*
- Where do all the products go when we no longer want them? *Mostly to landfills.*
- When does an object become waste? *When it becomes spoiled, ruined, dirty, ugly, broken, old, no longer useful.* Make sure that students understand that once an object is thrown into a landfill, the object can no longer be used. The natural resources used to make the object end up in the landfill and are therefore wasted.
- What is valuable? *Whatever you think is important.* When does a new thing lose its value? *When someone who has it doesn't want it anymore; when it breaks or becomes soiled; when it gets old.*
- What can be done with things we no longer want, instead of throwing them into a trash can? *They can be given to someone else; reused; made into something else; recycled.*

Students from Nona Reimer's fifth-grade class at John Malcom Elementary School construct a model landfill in a bottle.

- Do you think landfills are a good idea? *Yes/No* If students say yes, ask them to explain. *We need landfills—a place where items that can't be reused or recycled can be thrown away.* If students say no, ask them what the alternative is. Where will people put their garbage? *They can recycle it or reuse it. They can try not to make garbage.* Can everything be either reused or recycled? *No.*
- Would most people want a landfill built next door to their homes? Why or why not? Where do we find areas for landfills? *Usually in areas where people do not live.* What is usually present in these areas*? Plants, animals, ecosystems.*
- Consider the distance that garbage trucks will need to travel to get to a landfill. What natural resources do trucks use to transport trash? *Fossil fuels.*

B. Discuss as a class the pros and cons of placing waste in landfills.

- Some pros to putting waste in landfills are listed below:
  - Garbage needs to go somewhere, and a landfill can handle large

amounts of waste, keeping it away from where people live.

- Placing garbage in a landfill is an easy way to dispose of unwanted items.
- The garbage is better contained in a landfill.
- The landfill keeps other places waste-free.
- A landfill can be designed to protect the environment.

• Some cons to landfills are listed below:

- A landfill takes up space where an ecosystem existed and makes it impossible for people and wildlife to use the land.
- A landfill is ugly.
- Heavy equipment working in a landfill create noise and dust.
- A landfill might pollute groundwater.
- Landfills can create unpleasant odors and attract insects and rodents.
- Materials that end up in a landfill are usually no longer available for people to use.

Note: If some concepts about landfills are not familiar to your students, you may want to introduce them briefly at this point or cover them in other lessons.

APPLICATION

A. Project the transparency of a "Diagram of a Landfill." Ask students to compare their landfills in bottles to the diagram of a landfill. Discuss what is similar and what is different.

Note: In the "Diagram of a Landfill," a "geotextile cushion" is added between the crushed rock and the liner. This keeps the rocks from piercing the liner. Above the crushed rock, another geotextile cushion keeps the soil from mixing with the rock. In this lesson the geotextile cushions were omitted in the landfill in a bottle to make it easier for the students to build the model.

Homework Assignment: Ask students to select an object discarded in a trash can. Ask them to describe how the object was made, what natural resources were used to make the object, how this object was used, why it ended up in the trash, and what will happen to it now. They can write this from the object's "point of view."

B. Ask students to share their homework assignments.

C. Introduce students to the waste management hierarchy listed below. Explain to students that because of the energy savings and the amount of natural resources conserved, this hierarchy serves as a way of setting up priorities for dealing with waste.

1. Reducing and reusing
2. Recycling and composting, including buying products made from recycled materials
3. Environmentally safe transformation (waste to energy) and environmentally safe land disposal (landfilling)

D. Ask students to focus on the chart, "What Goes in a Garbage Can?" developed at the beginning of this lesson. Ask students to tell you, as you circle items using different colored markers, which items on the chart could be reduced (i.e., used more sparingly in the first place), reused, or recycled. The chart can be used for reference, as a record of changes as the students learn more, and as an assessment tool.

E. Project a transparency of "Waste Stream from Schools." Ask students to look at the "Schools" column and to indicate what natural resources each came from. Then have them identify which could be reduced, reused, or recycled.

Project Idea: Have groups of students research the location of the landfill where their garbage goes and to identify any nearby streams or other bodies of water. Have them find the source of their community's drinking water. If the landfill is not located in their community, have students find out the source of the drinking water of the community in which the landfill is located. Then discuss with students how the landfill might impact the community's drinking water.

Project Idea: Have groups of students collect and analyze water samples of surface water surrounding a landfill. They should share their results with community members.

At least four weeks later

A. Provide plastic or garden gloves to each pair of students and have them sort through their landfills. Discuss with students:

1. What was the condition of the items when they were removed from the

model landfills? Was anything rotting? Explain to students that garbage placed in landfills usually does not rot because there is not enough air and moisture to help things to decompose. (The topic of decomposition is addressed in the 4–6 Module, Unit 3.)

2. Was it easy to take the trash out of the students' landfills and to separate it? Would it be easy or difficult to try to separate the trash from a real landfill? What would be some problems? Explain to students that some communities have a materials recovery facility (MRF) where all types of garbage are separated before the nonrecyclables are transported to a landfill. However, once the garbage has been covered with soil in a landfill, it is very difficult and would be very expensive to try to remove all the items that could be reused and recycled. Therefore, it is more efficient to separate the recyclable and usable materials before the trash is buried in the landfill.

Note: For more information and a lesson on MRFs, see the 4–6 Module, Unit 2, Lesson 8, and Appendix B–III.

3. What items in the models of landfills (including the containers themselves) should be reused, recycled, or put in a landfill after this lesson? For example, most communities recycle the two-liter PETE bottles (polyethylene terephthalate); organic wastes, such as banana peels and leaves, can be composted / mulched; pennies can be reused; newspaper can be recycled / mulched; aluminum can be recycled; cloth can be reused or, if made from cotton, silk, wool, or other all-natural fiber, can be mulched or composted.

B. Keep these models of landfills to use in the 4–6 Module, Unit 4, Lesson 2, when students will learn more about leachate and what household waste should not go into a garbage can and end up in a landfill.

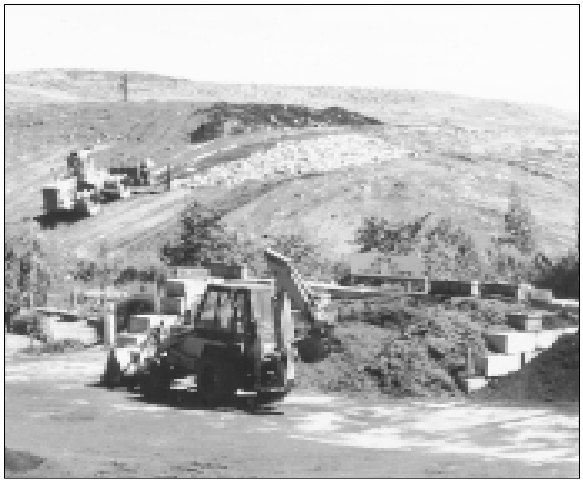
FIELD TRIP

Take students on a field trip to see their local landfill, transfer station, or MRF. If your community has a transfer station, explain to students its purpose. A transfer station is a place that is usually located closer to residential and commercial areas than a landfill. Waste is temporarily stored there and then loaded on large trucks and hauled to the landfill.

If a field trip is not possible, consider taking slides or making a video of the landfill and show these to the class; or invite the local waste manager or recycling coordinator to visit the class and bring slides or a video of the landfill.

When observing a landfill, students should realize that it would be quite difficult to separate trash once it is placed in the landfill.

A landfill in Sonoma County.



A landfill in Sonoma County. In the background the day's garbage is being covered with soil. In the foreground compost is available for sale.

VARIATION

Have students weigh the garbage before they place it in their model landfills. Then once they have removed the garbage and separated it, have students calculate the total weight for items that could be reused, those that could be recycled, and those that need to be placed back in the landfill. This will indicate how much garbage, by weight, can be diverted. Trucks with garbage are weighed at the landfill and their drivers pay to dump their garbage, based on the weight of the garbage.

Note: In a landfill the volume of materials is more important than the weight, because it is the volume of garbage that takes up space. Have students figure out how they can measure the volume (i.e., how much space the garbage takes up) of their garbage.

EXTENSIONS

A. Ask students to make a map of current and former landfills in the community. Ask if they can think of reasons why landfills might be placed in certain areas (e.g., areas of low population, areas designated for industrial use) and what a landfill's impact might be on the surrounding community.

B. Ask students to draw and label what they can do to keep more garbage out of the landfill.

RESOURCES

Videos

Bill Nye the Science Guy: Garbage. Elk Grove Village, Ill.: Disney Educational Products, 1995. (50 minutes)

In addition to other information about waste, Bill Nye shows that garbage usually does not decompose in a landfill.

Garbage, Garbage, Garbage. The Green Earth Club series. Produced by TV Ontario, 1992 (15 minutes). Chatsworth, Calif.: AIMS Media (distributor).

Shows a landfill site and explains what usually happens to garbage after it leaves our homes.

It All Adds Up (Waste/Pollution). The Outside Story with Slim Goodbody series. Produced by Agency for Instructional Technology (AIT) and the Slim Goodbody Company, 1991 (15 minutes).

Stresses the importance of dealing with waste responsibly and shows various ways in which humans dispose of waste. Encourages students to reduce, reuse, and recycle as much of the waste they create as possible.

Kids Talkin' Trash. San Leandro, Calif.: Alameda County Waste Management Authority, 1995 (14 minutes). Sacramento: California Integrated Waste Management Board (distributor).

Students learn how to make less garbage and protect the environment by practicing the four R's: reduce, reuse, recycle, and rot. Shows a landfill.

Books

Amos, Janine. *Waste and Recycling.* Chatham, N.J.: Raintree, 1992.

Discusses what waste is and how it can be recycled.

Bottle Biology Resources Network. "Compost Column." Madison: University of Wisconsin, March 1990.

Website

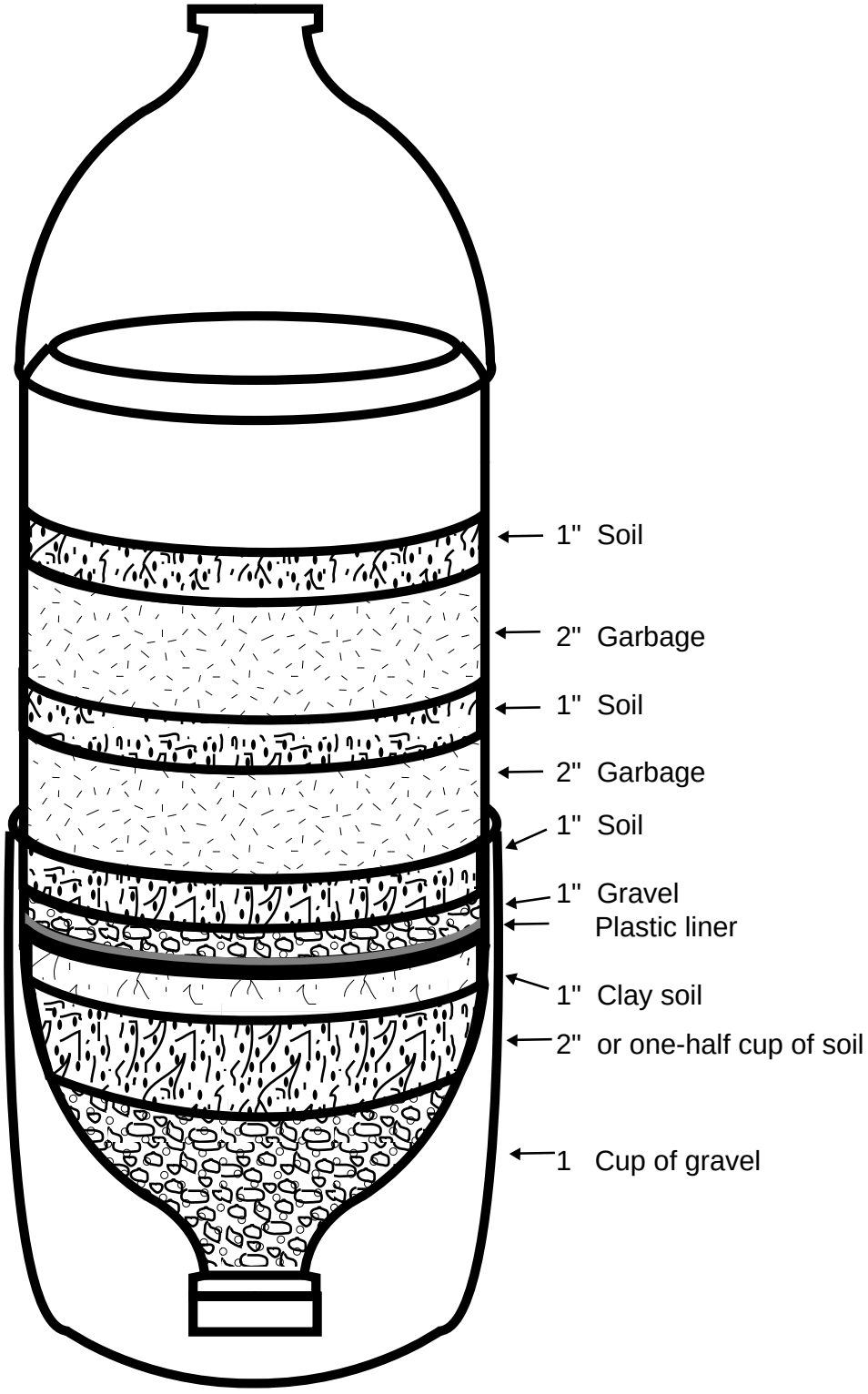
See "Appendix F–III, Landfill Websites."

Transparency

CONSTRUCTION OF A LANDFILL IN A BOTTLE

Transparency

LAYERS IN A LANDFILL IN A BOTTLE



Transparency

DIAGRAM OF A LANDFILL

4–6 Module
Unit 1

Transparency

WASTE STREAM FROM SCHOOLS[1]

Material	Schools' waste (percent by composition)	Major category of natural resources used to make this product.	Can this item be reduced, reused, recycled, composted?
PAPER	total: 53.9%	*plants*	*reused*
Corrugated / Kraft	2.2%		
Newspaper	0.6%		
Office paper	1.9%		
Mixed paper	16.2%		
Other	33.0%		
GLASS	total: 1.1%		
Clear bottles / containers	1.0%		
METAL	total: 2.6%		
Ferrous metals	0.9%		
Nonferrous metals	0.3%		
Other	1.4%		
PLASTIC	total: 11.9%		
HDPE	0.6%		
PET	0.2%		
Film plastic	7.4%		
Other plastic	2.7%		
Other	1.0%		
OTHER ORGANIC	total: 26.8%		
Food	22.9%		
Yard / landscape	3.5%		
Other	0.4%		
OTHER INORGANIC	0.5%		
HOUSEHOLD HAZARDOUS WASTE	2.6%		
MIXED RESIDUE	0.5%		

[1]City of Los Angeles 1995 Waste Composition Sampling Table 4-9, "Disposal Composition for Education–Public Primary / Secondary Target."

BACKGROUND INFORMATION FOR THE TEACHER

In 1997 Californians generated approximately 52.5 million tons of garbage. Only 32 percent of the discarded materials were recycled and composted.[2] The rest of the discarded materials were thrown "away." But where is this "away"? For most people in California, "away" is the landfill where, in 1997, 68 percent of the waste (including some discarded materials that could have been reused or recycled) was dumped. But the discarded materials in a landfill do not go away. They occupy space in the landfill. Materials buried in a landfill decompose slowly, because the conditions are not ideal for rapid decomposition by decomposers, many of which need oxygen and moisture. (For more information about decomposers, see the 4–6 Module, Unit 3, Lesson 2.) Note that some decomposers, such as anaerobic (those that do not need oxygen) bacteria also decompose garbage in a landfill. Some drier parts of a landfill are "mummified" for awhile, but as time goes by moisture in the site moves around to different locations and decomposition takes place. What takes five or ten years in a wet landfill to decompose might take 30 to 50 years in a dry landfill site.[3]

A landfill is not the best place for garbage that can be reduced, reused, or recycled. Instead of reusing objects or using waste materials to make new products, some communities bury waste materials in landfills, and they are potentially lost to those communities forever. Furthermore, all of the natural resources and energy used to make the items that are now in a landfill are wasted and are no longer available to people and other living things. Unburying and separating items for reuse or recycling would be cost-prohibitive at this time.

In addition, large areas of land are used for landfills. These areas were once ecosystems, providing habitats for wildlife and plant life. Also, people could have used the areas for a variety of purposes, such as parks or home sites.

However, landfills are essential, because people need a place to put their garbage where it will be contained and kept from contaminating the environment. Landfills are required by law to incorporate special design features to protect the environment. For example, the landfill operators must conduct methane monitoring to ensure that gases given off by the decaying garbage do not become a health risk or pollute the environment. The methane gas can be collected at a landfill and is often used as a source of energy.

Another landfill feature that helps to protect the environment is the use of an impervious clay layer and a synthetic plastic membrane at the landfill site. A geotextile cushion, crushed rock, another layer of cushion, and soil are placed on top on the plastic membrane before refuse is added. Sometimes a cushion is also placed below the plastic membrane. These features keep the potentially hazardous liquid, called leachate, which accumulates when rainwater leaches through the garbage, from contaminating groundwater.

Leachate can run off from the landfill and contaminate streams and other surface waters. If leachate from a landfill seeps down and reaches the water table, it can contaminate groundwater. With over half of all Americans dependent on groundwater for their drinking water, contaminated groundwater constitutes a significant problem. Therefore, landfill operators are required to install a leachate collection system to collect and remove the leachate that gathers at the base of the landfill. The groundwater and surrounding surface waters must be regularly monitored for contaminants from the landfill. (More information on leachate and its hazards to groundwater is provided in the "Background Information for the Teacher" in the 4–6 Module, Unit 4, Lesson 2. Also, see "Appendix B–IV, Landfill Issues.")

Every day dump trucks deliver tons of garbage and discarded materials to landfills. Throughout the day the garbage is compacted with heavy machines. A layer of soil is placed over the garbage to keep it from creating foul odors and to keep animals, including insects, from getting into the garbage and spreading it around. Landfill operators will sometimes use a substitute cover if soil is hard to find. This substitute material may be ground or chipped old tires, green waste, or special woven tarps made from plastic.

[2] "Estimated California Waste Tonnages and Diversion Rates." Information sheet. Sacramento: California Integrated Waste Management Board, November, 1998.

[3] Written communication from Joe Haworth, Information Officer, County Sanitation Districts of Los Angeles County, October 22, 1998.

Once landfill sites have reached capacity, they must be capped (closed with layers of clay and soil) and monitored. Such sites are often landscaped and used for parks, golf courses, hiking and equestrian trails, and open spaces. Some problems have resulted from the buildup of explosive methane gas and the settling of buried trash. Engineers and scientists are working on ways to make these sites safe for people and wildlife.

The California Integrated Waste Management Board (CIWMB) is responsible for implementing the Integrated Waste Management Act (AB939), which is a comprehensive set of laws, passed in 1989, designed to address California's solid waste problems and lessen the demand on natural resources. One of the laws (Public Resources Code Section 41780) states ". . . the city or county shall divert 50 percent of all solid waste by January 1, 2000, through source reduction, recycling, and composting activities . . .."[4] The measurement of achievement for this goal is not a comparison from one year to another. Instead, in the year 2000, of all the solid waste generated, at least 50 percent must be diverted. Students can help to reduce solid waste through reducing, reusing, recycling, and composting. For more information on waste management-related legislation, see "Appendix B–I, History of Waste Management."

The integrated waste management hierarchy promoted by the California Integrated Waste Management Board emphasizes the following priorities concerning products and packaging:

1. Reducing and reusing

2. Recycling and composting

3. Environmentally safe transformation (waste-to-energy) and environmentally safe land disposal (landfilling)

"Although there are not many waste-burning plants in California, there are two large waste-to-energy facilities in southern California. With the low price of electricity and the general opposition to burning things in California, there has been a deemphasis on waste-to-energy, but there are people whose communities use those plants—mainly the cities of Commerce and Long Beach."[5] For more information on waste-to-energy facilities, see "Appendix B–V, Incineration: Waste-to-Energy Facilities."

Understanding the role landfills play in managing our waste and their potential environmental impacts will enable us to use our natural resources in a more efficient manner.

[4]Written communication from John Sitts, Supervisor, Waste Analysis & Methods Section, Waste Analysis Branch, California Integrated Waste Management Board.

[5]Written communication from Joe Haworth, Information Officer, County Sanitation Districts of Los Angeles County, October 22, 1998.

The Ogden-Martin waste-to-energy facility receives four tons of garbage daily from the county of San Juaquin and the city of Modesto, which is deposited by 20-ton garbage trucks into the waste storage pit. The crane collects this garbage and feeds the two combustion units that generate 21.5 megawatts of electricity per hour. Photo courtesy of Ogden-Martin.

LESSON 4: Packaging: What a Waste!

LESSON'S CONCEPTS

- Packaging is useful and necessary for many reasons.
- Packaging is a major component of the waste stream. People can reduce the amount of garbage they generate by making thoughtful and informed choices when they buy packaged products.
- Excessive packaging and processing can waste natural resources and increase the amount of solid waste requiring disposal.

PURPOSE

Students will learn the purposes of packaging and how excess packaging contributes to the solid waste requiring disposal.

OVERVIEW

In this lesson students will:

- Determine the purposes of a variety of packaging.
- Identify the materials used in packaging.
- Compare the amount of packaging and costs of the same product when placed in a large package as compared to being packaged in individual containers.
- Work in groups to compare the costs of various potato products that are processed and packaged differently.
- Classify packaging according to categories, based on the purpose or function of the packaging.
- Evaluate wasteful packaging.
- Recognize packaging made from recycled materials.

CORRELATIONS TO CALIFORNIA'S CONTENT STANDARDS AND FRAMEWORKS AND TO *BENCHMARKS FOR SCIENCE LITERACY*

- Students classify packaging according to categories, based on the purpose or function of the packaging.
  - "There is no perfect design. Designs that are best in one respect (safety or ease of use, for example) may be inferior in other ways (cost or appearance)." (*Benchmarks for Science Literacy*, page 49)
  - "Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept . . . Students will: classify objects . . . based on appropriate criteria . . .." (*Science Content Standards, Grades K–12*; Grade 5; Investigation and Experimentation, Standard 5a)
- Students compare the amount of packaging to the size and cost of a product. They also compare the ways potatoes and potato products are packaged.
  - "Students organize, represent, and interpret numerical and categorical data and clearly communicate their findings." *(Mathematics Content Standards for California Public Schools, Kindergarten Through Grade Twelve*, page 18)
  - "Students will: . . . record data using appropriate graphical representation (including charts, graphs, and labeled diagrams), and make inferences based on those data . . .." (*Science Content Standards, Grades K–12*; Grade 5; Investigation and Experimentation, Standard 6g)

SCIENTIFIC THINKING PROCESSES

observing, communicating, comparing, classifying, relating

TIME

30–60 minutes to prepare for the lesson; 45–60 minutes for each of the four sections

VOCABULARY

packaging

PREPARATION

___ **1.** Read the "Background Information for the Teacher" at the end of this lesson.

___ **2.** Make a transparency of "Energy for Making a Cardboard Box" (page U2–109).

___ **3.** Ask students to bring samples of:

- Nature's packaging (e.g., bananas, oranges, apples, nuts)
- Packaging that could be reused (e.g., cottage cheese containers and other plastic containers, plastic bags, paper bags)
- Packaging that could be recycled (e.g., aluminum and tin cans, foil wrap)
- Excessive packaging or packaging that is difficult to recycle (e.g., polystyrene from meat trays; individually wrapped packets; packaging combining metal and paper with plastic, such as boxed juices)

Note: Each student should bring only one example of any of the packaging listed in "Preparation" step "2."

___ **4.** Make copies of "Purpose or Function of Packaging" for each group of three or four students (pages U2–110 and U2–111).

___ **5.** Obtain a large bag of potato chips and the same amount of potato chips (by weight) in small individual packages (the same brand of chips should be bought for accurate cost comparisons). Keep receipts for cost comparisons.

Note: If small individual packages of potato chips are not available, use another product (e.g., crackers or cookies) that come in a large bag / box and in individually packaged bags / boxes.

___ **6.** Purchase five food items packaged in the following ways and label "A," "B," "C," "D," and "E":

A. A product in a plastic container (e.g., yogurt)

B. A product in packaging made from recycled material (e.g., cereal in a cardboard box)

C. An apple, banana, or other fruit

D. A product in an aluminum can (e.g., soda)

E. A product which has eye-catching and excessive packaging, wrapped in more than one layer so that the product appears larger (e.g., fancy cookies, candy, or a toy)

___ **7.** Make a transparency of "A Spud by Any Other Name 1" (page U2–112). If

(Use school's letterhead.)

Dear Parent or Guardian,

Please read the following information with your child:

Our class is studying packaging. Students will analyze why products are packaged and which products appear to be overpackaged (and therefore add to our solid waste). Would you please collect and send with your child one example of any of the following food packaging:

- Nature's packaging (for example, banana, orange, apple, nut)
- Packaging that could be reused (for example, cottage cheese container and other plastic containers, plastic bags, paper bags)
- Packaging that could be recycled (for example, aluminum and tin cans, foil wrap)
- Excessive packaging or packaging that is difficult to recycle (for example, polystyrene from meat trays; individually wrapped packets; packaging combining metal and paper with plastic, such as boxed juices).

Please rinse these packages, if needed, and have your child bring them to class on _____ .

Your cooperation in this matter is greatly appreciated.

Thank you,

you want your students to complete the calculations in the price and pound column, make a copy of "A Spud by Any Other Name 2," for each group of students (page U2–113).

___ **8.** Make a copy of "Analyzing the Cost and Packaging of a Product" for each group of two or three students (page U2–114).

MATERIALS

For "Pre-Activity Questions"

___ The transparency, "Energy for Making a Cardboard Box"

For "Part I, Looking at the Purpose or Function of Packaging"

___ Samples of different types of food packaging (e.g., paper boxes, metal cans, plastic bottles and bags, glass containers, foil wrappings, polystyrene trays) brought by students

___ A copy of the chart, "Purpose or Function of Packaging," for each group of three or four students

For "Part II, Comparing the Size of the Package to the Amount of the Product"

___ Weight scale

___ A large bag of potato chips and the same amount of potato chips in small individual packages (or other products that come in a large bag and in small individual packages)

Note: If students are planning to eat the potato chips, provide a bowl in which the chips can be placed before the empty bags are weighed. If students will be handling the chips to weigh them, provide plastic gloves for students who will be handling them to keep the chips from getting contaminated.

For "Part III, Analyzing Ways Potatoes and Potato Products Are Packaged"

___ A transparency of "A Spud by Any Other Name 1" (If students will be calculating costs, then make a copy of "A Spud by Any Other Name 2" for each group of three or four students.)

___ Calculator (if using "A Spud by Any Other Name 2") for each group of three or four students

___ The chart, "Analyzing the Cost and Packaging of a Product," for each group of two or three students

PRE-ACTIVITY QUESTIONS

A. Ask students:

- What products usually come in packages? *Many food items, cosmetics, toys.*
- What products usually do not come in packages? *Clothing, fruits and vegetables, books.*

B. Tell students that in this lesson, they will focus on the packaging of food items. Ask students:

- What types of food come in packages; i.e., packaging that people make? *Canned foods; frozen foods; perishable foods; drinks; snacks, like potato chips.*
- What types of food usually do not come in packages? *Fresh produce, items sold in bulk (in barrels or bins).*

C. Ask students to identify food items that are packaged in the following ways:

- Paper or cardboard; *e.g., cookies, cereal, eggs, cubed butter*
- Plastic; *e.g., noodles, salad mixes, candy, catsup*
- Aluminum; *e.g., soft drinks, other drinks*
- Steel / tin; *e.g., soup, canned vegetables, pet food*
- Glass; *e.g., fruit juice, vegetable oil, mayonnaise*
- Mixed materials; *e.g., boxed fruit juices, pet food in a bag*

D. Discuss which categories of natural resources were used to produce the packaging. For example:

Students from Janet Cohen's sixth-grade class at Gold Trail Elementary School look at various types of packaging.

- Paper or cardboard; *trees (plants)*
- Plastic; *fossil fuels (energy sources)*
- Aluminum; *minerals*
- Steel / tin; *minerals*
- Glass; *minerals*
- Mixed materials; *more than one natural resource, such as trees and fossil fuels*

E. Show the transparency of "Energy for Making a Cardboard Box." Ask students to explain how energy is used to produce packaging. *To grow trees; to harvest trees; to obtain petroleum for energy, for transporting trees and the processed materials; to provide electricity to operate the lumber mill, manufacturing plant, packaging business, and store.*

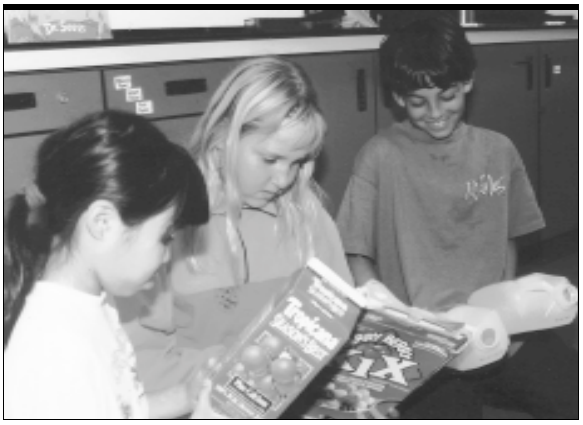
PROCEDURE

Part I, Looking at the Purpose or Function of Packaging

In this activity students determine why food products are packaged a certain way.

A. Introduce the activity by passing around samples of different types of food packaging which the students brought to class. Ask students to identify the purpose or functions of food packaging. That is, why is the product packaged in that way? Develop a class list. For example, the purpose or function of the package is for:

- Preservation of product: to keep food fresh
- Protection of product: to keep the contents from damage during shipping
- Sanitation: to keep the item clean and uncontaminated
- Consumer safety: to prevent tampering (e.g., having someone add something harmful to the product)
- Complying with regulatory standards imposed by government regulations
- Identification of product: to identify the product inside the package
- Theft protection: to prevent the item from getting stolen
- Provision of instructions: To provide instruction on how to use or prepare the item in the package



Students from Nona Reimer's fifth-grade class at John Malcom Elementary look at various types of packaging.

- Convenience: to make it easier to carry home; to keep small items together
- Advertising: to make you want to buy it

B. Collect the packaging that students brought.

C. Divide the class into five groups and provide each group with the chart, "Purpose or Function of Packaging," and one food package.

- As the groups complete their charts for one item, allow them to pass their packages to other groups so that each group analyzes a total of five packages.
- Ask students to complete "Part I" on their chart, "Purpose or Function of Packaging."
- Have students report what they learned.
- Discuss with students:
  - From what materials were various packaging made? *Plastic, paper, aluminum.*
  - Which packaging seems most important? *The one for the preservation and protection of the product.* (Answers will vary.) Have students offer explanations for their answers.
  - Which product has the most packaging?
  - Is there any packaging that is making the item seem bigger and more eye-catching? If so, why was the item packaged in that way? *To make you want to buy the product.*

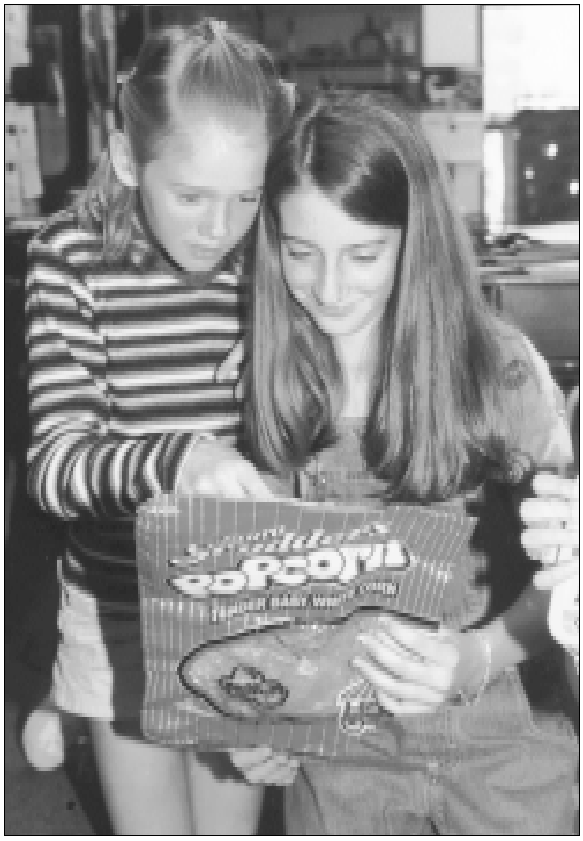
- Did any packaging appear unnecessary or excessive? Have students offer explanations.
- Why is excessive packaging a problem*? It uses up too many raw materials and usually gets placed in a landfill after one use.*
- Of the packaging that was most excessive, what materials and natural resources were used in making the packaging? *Cardboard (trees), plastic (fossil fuels).*
- How could the packaging have been made in order to conserve natural resources? *Less packaging used; packaging made from recycled materials; packaging that could be recycled.*

- What do people usually do with the packaging after they use the product? *They throw it into a garbage can. Sometimes they throw it on the ground and it becomes litter.*
- Where does packaging go when it is thrown in a garbage can? *To the landfill.*
- Can something else be done with the packaging? *Some packaging might be reused or recycled.*
- What could be recycled? (The answer will depend on what is currently accepted for recycling in your community.) *Aluminum cans, glass jars, plastic bottles.*
- What packaging was made from recycled products? How do we know that a package is made from recycled products? (These packages usually have the standard recycling logo with the three arrows printed on the package.) Why is it a good idea to buy packages made from recycled products? *This conserves natural resources because fewer raw materials were probably needed to make the recycled products.*

CARTON MADE FROM 100% RECYCLED PAPER

MINIMUM 35% POST-CONSUMER CONTENT

A student from Valley Oak Elementary School examines a package.



Two students from Nona Reimer's fifth-grade class at John Malcom Elementary School examine a package.

Note: The goal of this activity is to learn what students understand at this point about what is desirable or necessary, undesirable or unnecessary, concerning packaging. Depending on the students' answers, you may wish to continue the discussion, especially if your school has begun a reducing, reusing, and recycling program or if students live in communities where there are recycling programs already underway.

D. Ask students to complete "Part II" in the "Purpose or Function of Packaging." Have groups report back to the class. Discuss with students:

- Which packages can be reused or recycled?
- How can we reuse the packaging?
- What will happen to the packaging we cannot reuse or recycle?

E. Ask students to complete "Part III" in the "Purpose or Function of Packaging." Conduct a discussion of their ideas.

F. Ask students whether they think the amount and type of packaging affect the cost of different food products. What percent of the cost of packaged foods do they think is due to packaging? Record students' guesses. Tell students that packaging can often add about 10 percent more to the cost of the product. This means that for every dollar (or 100 cents) they spend, 10 cents goes to packaging.

G. Discuss the following with students:

- What are the advantages of packaging?
- How can packaging actually reduce the volume of waste of the items inside the packaging? *By reducing spoilage and damage of these items.*
- Is packaging necessary for all types of food? Have students explain their answers.
- Which packaging is least wasteful of natural resources? Which is most wasteful? What criteria might you consider when deciding whether packaging is necessary or wasteful?
- Which of your favorite foods could you buy without packaging?
- What should we do with the packaging that everyone brought to class? (Some of it can be used in "Application.")

Note: You might want to keep the packaging for arts and crafts projects and / or for Lesson 10.

Part II, Comparing the Size of the Package to the Amount of the Product

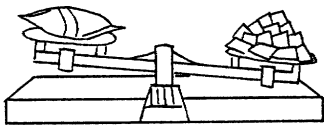
In this activity students compare the sizes of the packages containing the same type of product, potato chips.

A. Show students a large bag of potato chips and the same amount of potato chips in small individual packages.

Note: If students are planning to eat the potato chips, the chips can be placed in a bowl as the bags are weighed. If students will be handling the chips to weigh them, have them use plastic gloves to handle the chips to keep them from getting contaminated.

1. Have students weigh the large bag of chips and the empty bag. Record both weights. Show students that they can subtract the weight of the bag from the total weight of the bag and chips to get the weight of the chips. (This information should also be on the package.) Students might want to check their subtraction figures and the accuracy of the weight indicated on the bag by weighing the contents of the bags.

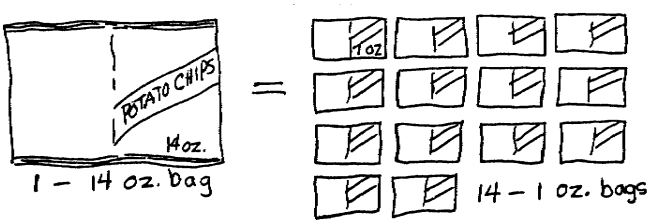
2. Weigh all of the small individual bags with the chips and then only the bags. Record the weights. Show students that they can subtract the weight of all the bags from the total weight of the bags and chips to get the weight of the chips. They can also use the weight information of the bag. If students want, they can check their subtraction figures and the accuracy of the weight indicated on the bags by weighing the contents of all the small bags.



3. Have students compare the weight of the large bag to the weight of all the small bags.

4. Ask students to cut the bags and spread out the packaging paper to compare the amount of paper used for the large bag to the total amount of paper used for the small bags. Include the large bag or box

in which the little bags came. This could be placed on a bulletin board for visual effect.

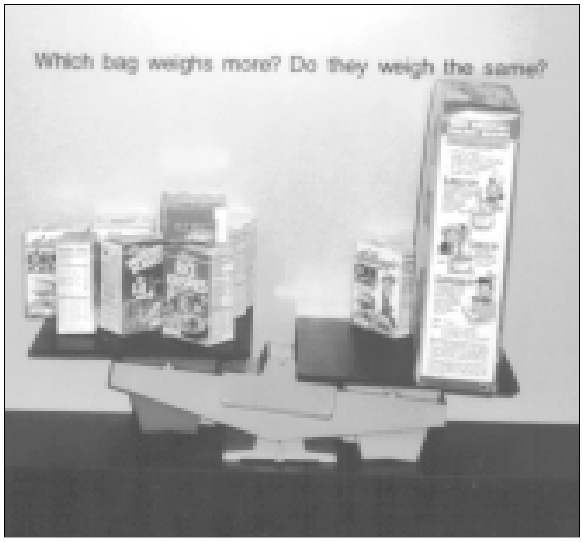


Note: Older students could calculate the area of the wrapper. To determine the area, students will need to measure and multiply the length times the width of the wrapper. So if the wrapper measured six inches by eight inches, the area would be 48 square inches.

5. Discuss with students:

- Which products could be bought in bulk or in large containers? *Fruits and vegetables, breakfast cereal, rice, beans, candy.*
- What are the advantages of buying items in large quantities (or in bulk)? *The item is less expensive per serving, and there is less packaging that goes to the landfill or that needs to be recycled.*

***Homework Assignment*:** Ask students to work in groups to create a display to show the packaging of a selected product. For example, a group can compare the amount of packaging of an economy-sized cereal box to several small individual-sized cereal boxes. They will need to get enough small boxes so that their total amount of cereal will equal the amount in the large box.



A comparison of weights of single-serving boxes to a multiple serving box is displayed at the Davis Street Educational Center, San Leandro, California; operated by Waste Management, Inc.

6. Ask students to guess how much of our trash is packaging. Tell them that it makes up to 40 percent of household garbage. Have students determine a way to graphically show 40 percent. This can be done using a graph or chart.

Students from Janet Cohen's sixth-grade class at Gold Trail Elementary School compare the weight of a large potato chip bag to small individual packages containing the same amount of potato chips.

7. Ask students what types of packaging the potato chips are in that they bring to school. Discuss other options for packaging these chips to create less waste. *Reuse the plastic bags; use reusable plastic containers.*

Part III, Analyzing Ways Potatoes and Potato Products Are Packaged

In this activity, students compare the packaging of the same type of product that is processed in different ways (e.g., fresh potatoes, instant mashed potatoes, canned potatoes).

A. Decide to do "Option 1" and "Option 2" if you want students to calculate the price per pound. Do "Option 2" only if you do not want students to do the calculations.

Option 1: If you want students to calculate the price per pound, provide a calculator and a copy of "A Spud by Any Other Name 2" to each group. Complete several calculations as a class until students understand how to do these calculations. Then ask the groups to complete the calculations for the rest of the products.

Option 2: If you do not want your students to calculate the price per pound (or if students have completed the calculations), project the chart "A Spud by Any Other Name 1" on an overhead projector and ask the following questions:

- Which forms of the potato seem to be most highly processed?
- Which forms are most expensive per pound?
- Which form of potato would you purchase if you were interested in reducing solid waste?
- Which form of potato would you purchase if you were interested in saving money?
- What relationships are there among cost, amount of processing, and packaging of products?

B. Ask students if packaging is necessary for all types of food. Encourage students to explain their answers.

C. If possible, take students to a grocery store. Otherwise, have students complete this assignment as homework. The chart may need to be adjusted if your community has small grocery stores.

- Divide students into groups of two or three.
- Instruct each group to choose a fresh food item to investigate, such as apples, peanuts, tomatoes, or corn.
- Provide the chart, "Analyzing the Cost and Packaging of a Product," for each group.
- Ask students to complete their charts for the fresh form of their product and for five different processed forms of the product (e.g., frozen, canned, whole, canned cut, creamed or pureed, dehydrated).
  - One way to do this is for group members to assign specific types of products for each student to research. If this approach is used, you will need to provide each student with a copy of the chart.
  - Another way to do this is for one student to volunteer to do the entire chart and bring it to class. The rest of the group members can then complete the calculations.

Note: Students should try to get the same type of weight measurements for easy comparison. You might need to explain to students that there are 16 ounces in one pound and encourage them to convert all products on their charts into ounces or pounds.

D. Have students within their groups consolidate their data on one group chart and present the results to the class.

E. After all groups have collected their data, conduct a whole class discussion, addressing the following questions:

- Which form of your food item is most expensive per pound? Why? Which form do you think takes the most energy to produce? (The concept of energy was introduced in the 4–6 Module, Unit 2, Lesson 2.)
- What relationships are there among cost, amount of processing, and packaging of products?
- Which of these products will you buy in the future?
- What criteria will you use for making your decisions about what to buy and what not to buy?

DISCUSSION/QUESTIONS

A. Ask students how they can reduce the amount of packaging they throw away. *Buy items with less packaging; buy items in packaging that can be recycled.*

B. Discuss the importance of packaging. Review the class list developed in "Part I" on the purposes of packaging. Then discuss the drawbacks or trade-offs of packaging. Make a class list of some drawbacks or trade-offs. For example:

- Packaging increases the cost of the product.
- Most packaging ends up in a landfill.
- Some packaging becomes litter and makes an area ugly and can injure people and wildlife.
- Packaging can make a product look bigger and better than it really is.
- Natural resources are used to make packaging.

APPLICATION

Homework Assignment: Ask students to record the type and amount of packaging that is thrown away or recycled for one week. One way to do this is to have students collect clean packaging in a separate cardboard box for one week and then record what was collected. Or, the students can peek in their garbage cans at the end of the day and record what they see. Students should also describe ways they can decrease the amount of packaging that is being thrown away or recycled at home.

A. Ask students to share their homework assignments.

B. Write the following on the chalkboard, but in a different order from the one below. Have students rate the following in order of least wasteful to most wasteful and explain their answers:

- No packaging
- Refillable (or reusable) packaging made from recycled products
- Packaging that is reusable
- Packaging made from recycled products and is recyclable
- Packaging that is made from recycled products
- Amount of packaging limited to one layer

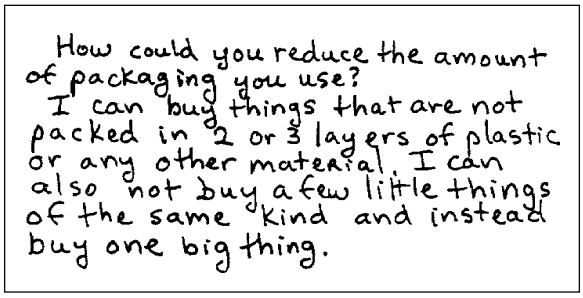
C. Have students in each group select one type of cookie they want to package. Students should decide what the purpose of the package should be. Then ask them to describe and draw the package and possibly make it. (Some packaging from "Part I" could be used.) Remind students to design packages which reflect their awareness of the importance of waste reduction.

D. Ask students to:

- Identify two environmental and/or waste management problems associated with packaging. *Litter and need for disposal*
- Design a list of recommendations for selecting and purchasing food products: For example:
  - Choose products in recyclable, returnable, or refillable containers.
  - Avoid excessive packaging (For example, avoid items that are packaged in plastic bubble wrap.)
  - Buy products in bulk and in larger sizes.
  - Buy unwrapped fruits and vegetables.
  - Avoid snack items in single-serving packages.
  - Support companies that provide minimal packaging and use packages made from recycled products.
  - Carry products home in cloth or string bags.

E. Ask students what action would be most responsible from the standpoint of reducing solid waste if they were asked at a grocery store whether they wanted paper or plastic bags. Students should be aware that bringing their own cloth or string bags is the best option. If a cloth bag is not available, students should consider that paper comes from renewable natural resources and plastic from nonrenewable natural resources. A paper bag can be reused several times and then recycled. However, a plastic bag could also be selected if a household reuses the plastic bag several times before recycling it, or uses it to line kitchen garbage cans (instead of buying new plastic bags).

F. Ask students to write in their journals how they could reduce the amount of packaging used with the items that they purchase.



Submitted by Janet Cohen, sixth-grade teacher, Gold Trail Elementary School, Gold Trail Union School District.

EXTENSIONS

A. Ask students to rank/order the food products investigated from "most packaging/processing" to "least packaging/processing" and construct a graph illustrating the relationship between cost and packaging. Then ask them to interpret and describe the graphed relationship in one to two sentences.

B. Assign students to prepare a personal plan for reducing the amount of excess packaging used with the items that they purchase.

C. Ask students to notice, at the grocery store, which brands of products seem most overpackaged. As a problem-solving activity, ask students to brainstorm ways they can convey their findings to companies that use excessive packaging. How can students address the issue as a mutual problem? What are likely to be the most effective ways to communicate? Assign students to test their ideas.

D. Have students analyze packaging of fast food restaurants. Ask them to identify how much packaging was used and whether the packaging is recyclable or reusable. If the packaging is reusable, how can it be reused? Encourage students to creatively reuse the packaging and bring their creations to class.

E. Have students analyze the following: If you buy things in larger containers, does it reduce waste? Students can compare six 6-oz. juice bottles to a 36 oz. juice bottle. Allow students to drink the juice and compare the amount and weight of the containers.

F. Have students conduct a survey in school lunchrooms or at snack booths. Find out why students buy a product. Did they consider how much product they actually bought and how much of what they bought (including packaging) ended up being thrown away?

RESOURCES

Videos

Recycling Is Fun. Oley, Pa.: Bullfrog Films, 1991 (12 minutes).

Three children explore the three Rs of recycling—reduce, recycle, reuse. To educate themselves, they visit a landfill, a recycling center, and their local supermarket to find out what they can do to help to manage solid waste. While visiting the grocery store, the children look for new products made from, or packaged in, recycled paper or plastic containers. They discover their own power to recycle and choose what they buy. For grades K–4.

Garbage Tale: An Environmental Adventure. Los Angeles, Churchill Films, 1990 (18 minutes).

A boy dreams that he visits a landfill and recycling center and learns about reducing, reusing, and recycling. Shows that one bag of groceries can create three bags of waste.

Books

Kalman, Bobbie. *Reducing, Reusing, and Recycling*. The Crabtree Environment series. New York: Crabtree Publishing Company, 1991.

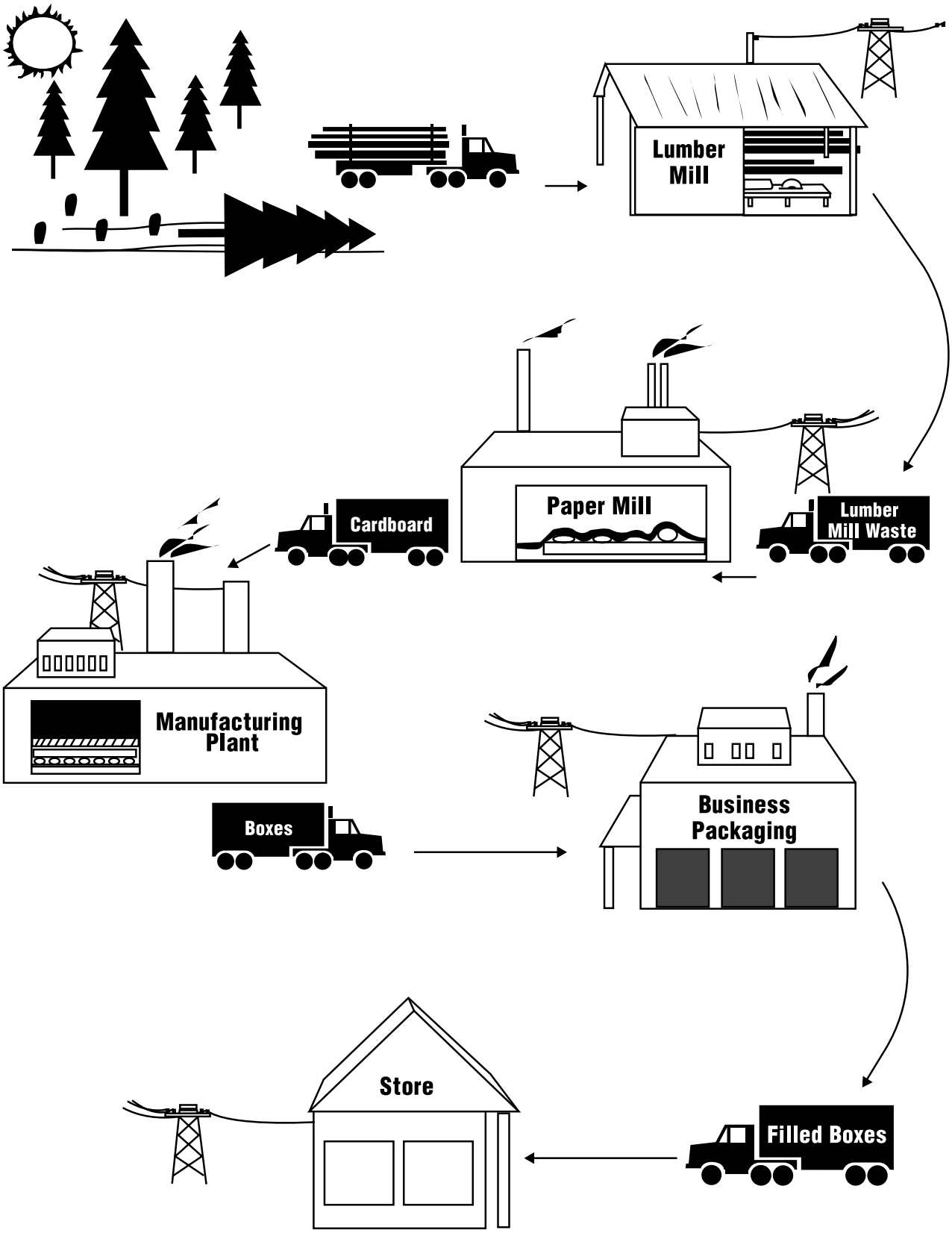
Describes the three Rs and how to become a wise consumer.

Harlow, Rosie, and Sally Morgan. *Garbage and Recycling.* Young Discoverers series. New York: Larousse Kingfisher Chambers, Inc., 1995.

Provides information about reusing, recycling, packaging, litter, and worms. Recommends activities for students to learn more about the solid waste problem and how to help solve it.

Transparency

ENERGY FOR MAKING A CARDBOARD BOX



Name:_____ Date: _____

PURPOSE OR FUNCTION OF PACKAGING

Part I. Write the name of each item for which you are analyzing the package. Check off the function or reasons for the packaging. Then check whether the amount of packaging is necessary (#12) or whether the product appears to be overpackaged (#13).

Function of or reason for the packaging

Name of item	*1. Preservation of product*	*2. Protection of product*	*3. Sanitation*	*4. Consumer safety*	*5. Complying with regulatory standards*	*6. Identification of product*	*7. Theft protection*	*8. Provision of instructions on how to use product*	*9. Convenience*	*10. Advertising*	*11. Other _____*	*12. Amount of packaging seems necessary*	*13. Appears to be over-packaged*
A _____													
B _____													
C _____													
D _____													
E _____													

Part II. Which of the items (listed under A, B, C, D, and E above) are packaged in:

A. Natural packaging (no paper, plastic, or other human-made materials)?

B. Reusable packaging?

C. Recyclable packaging (packaging that can be recycled)?

D. Nonrecyclable packaging?

E. Packaging made from recycled materials?

Part III. Select one of the products and its packaging. Describe another way that this product could have been packaged. You can illustrate your newly designed package.

Transparency

A SPUD BY ANY OTHER NAME 1

Product	Package size	Price	Price/pound (lb.)[1]	How packaged
Fresh russet potatoes	5 lb.	$ .99	$ 0.20	Plastic bag
Fresh russet potatoes	10 lb.	$ 1.69	$ 0.17	Plastic bag
Fresh russet potatoes	4 lb.	$ 1.00	$ 0.25	Bulk
Canned potatoes—sliced	15 oz.	$ .75	$ 0.80	Can (steel)
Canned potatoes—whole	15 oz.	$ .75	$ 0.80	Can (steel)
Tater tots—frozen	32 oz.	$ 2.85	$ 1.43	Plastic bag
Tater tots—frozen	5 lb.	$ 5.55	$ 1.11	Plastic bag
Mashed potatoes—frozen	22 oz.	$ 2.39	$ 1.74	Plastic bag
Hash brown patties—frozen	24 oz.	$ 2.39	$ 1.60	Cardboard box
Hash browns (southern style)—frozen	32 oz.	$ 2.79	$ 1.40	Plastic bag
French fries (crinkles)—frozen	32 oz.	$2.75	$ 1.38	Plastic bag
Shoestrings potatoes—frozen	20 oz.	$ 2.17	$ 1.74	Plastic bag
Potato chips	9 oz.	$ 2.09	$ 3.72	Plastic bag
Potato chips	14 oz.	$ 2.99	$ 3.42	Plastic bag
Instant mashed potato buds	5.5 oz.	$ .99	$ 2.88	Cardboard box
Instant mashed potato buds	13.75 oz.	$ 2.45	$ 2.85	Cardboard box
Instant mashed potato buds	1 lb. 12 oz.	$ 3.75	$ 2.14	Cardboard box
		$	$	
		$	$	
		$	$	

1 lb. = 16 oz.

[1]Prices gathered in Lakeport, California on July 25, 1997.

A SPUD BY ANY OTHER NAME 2

Product	Package size	Price	Price/pound (lb.)[1]	How packaged
Fresh russet potatoes	5 lb.	$ .99		Plastic bag
Fresh russet potatoes	10 lb.	$ 1.69		Plastic bag
Fresh russet potatoes	4 lb.	$ 1.00		Bulk
Canned potatoes—sliced	15 oz.	$ .75		Can (steel)
Canned potatoes—whole	15 oz.	$ .75		Can (steel)
Tater tots—frozen	32 oz.	$ 2.85		Plastic bag
Tater tots—frozen	5 lb.	$ 5.55		Plastic bag
Mashed potatoes—frozen	22 oz.	$ 2.39		Plastic bag
Hash brown patties—frozen	24 oz.	$ 2.39		Cardboard box
Hash browns (southern style)—frozen	32 oz.	$ 2.79		Plastic bag
French fries (crinkles)—frozen	32 oz.	$2.75		Plastic bag
Shoestrings potatoes—frozen	20 oz.	$ 2.17		Plastic bag
Potato chips	9 oz.	$ 2.09		Plastic bag
Potato chips	14 oz.	$ 2.99		Plastic bag
Instant mashed potato buds	5.5 oz.	$ .99		Cardboard box
Instant mashed potato buds	13.75 oz.	$ 2.45		Cardboard box
Instant mashed potato buds	1 lb. 12 oz.	$ 3.75		Cardboard box
		$		
		$		
		$		

1 lb. = 16 oz.

Student's Page

ANALYZING THE COST AND PACKAGING OF A PRODUCT

Product	Package size	Price	Price/pound (lb).	How packaged
1.		$	$	
2.		$	$	
3.		$	$	
4.		$	$	
5.		$	$	
6.		$	$	

BACKGROUND INFORMATION FOR THE TEACHER

There are many influences on what children buy—family food buying practices (e.g., buying fast foods, processed foods, frozen foods, fresh foods), advertising, packaging, socioeconomic factors, convenience, education, and beliefs. If children are to become responsible shoppers, there are many factors they should consider when they shop: (1) What kind of packaging does the food have? Is it necessary? Is it reusable? Is it recyclable? (2) What types of natural resources are consumed to create the packaging? Can these resources be recovered through reuse or recycling? and (3) What are the differences in the overall cost of foods? Food costs include such considerations as the amount of food in each package, the amount of packaging, and the comparative cost of disposing of waste versus reusing or recycling the package. Minimizing packaging material can make a big difference in the amount of solid waste that is produced.

At an early age children need to understand that when they buy something, they also buy the packaging. As responsible citizens they should see that the packaging of the products they buy is minimal, that it does not become litter, and that it is reused or recycled, if possible. If it is waste, they need to know how and where to dispose of it properly.

Packaging protects the contents from physical damage and spoilage and may also be used to ensure that the contents are sanitary. Labels on packaging identify contents and provide directions for use. Packaging may help retailers advertise their goods, keep sales records straight, and discourage theft. Packaging also provides consumer convenience.

By reducing spoilage and damage and by dividing food and beverages into individualized portions, packaging can actually reduce the volume of solid waste, because less food would be thrown away. Unfortunately, packaging also contributes substantially to the volume of solid waste needing disposal, depletes natural resources, adds to litter and pollution, and increases the cost of a product. Most packaging is meant to be disposed after one use. Some packaging materials contribute nonbiodegradable or toxic materials to the environment. Most litter is packaging and includes cans, bottle, paper wrappers, and bags. This type of litter has adverse effects on tourism and may also harm or kill wildlife.

In the United States, packaging accounts for 50 percent of all paper produced, 90 percent of all glass, 11 percent of all aluminum, and 3 percent of all energy used. Packaging makes up about 50 percent by volume and 30 percent by weight of municipal solid waste.[2]

Excessive packaging typically increases the cost of products. If consumers can relate their purchase costs to the amount of waste generated by packaging, they will realize they can save money by purchasing products with less packaging and buying products in bulk.

Packaging's manufacturing, distribution, and retail process generally fails to account for the cost of package disposal. Since this cost is not included in the cost of the product, the product sells for less than it would if the cost for disposal were included. However, consumers do eventually pay for the costs associated with package disposal in the form of higher fees for garbage collection, landfill and incinerator operations, and the clean up of litter. Without reusing or recycling packaging materials, the energy and natural resources that go into packaging are buried in landfills.

For more information on packaging, see "Appendix B–II, Waste Prevention."

[2]G. Tyler Miller, Jr. *Environmental Science: Working with the Earth* (Fifth edition). Belmont, Calif.: Wadsworth Publishing Company, 1995, p. 340.

Appendices

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